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On a simple and practicable Method of Measuring the Relative Apparent Brightnesses or Magnitudes of the Stars with considerable Accuracy. By Professor Pritchard.

Circumstances not generally interesting here to detail have recently diverted my attention from other astronomical work to what is conventionally meant by the magnitudes of the stars. It may be sufficient here to say that, having just completed the reduction of the relative coordinates of 250 stars in the cluster 39 Messier in the constellation *Cygnus*, for comparison by other astronomers at some remotely future period, I felt that perhaps only one-half of the work was done, unless some reliable measures of the relative magnitudes of the stars could be secured. Prof. Pickering's most interesting researches into the results obtainable from accuracy in star magnitudes also weighed on my mind. On consulting the various authorities on the subject, I found the question, whether of result or of method, somewhat in a chaos, so far as any considerable degree of accuracy was concerned. Even Struve, for instance, with all his care, gives on some occasions not less than three different magnitudes for the same star.

In this perplexity, I applied myself to the attempt of devising some method, which might land me in greater certainty, and after some time I hit upon a method which, after applying it to sixty stars, promises certainty, to the extent of one-tenth of a magnitude, in all the stars yet examined, from *α Lyræ* to the stars of least brightness estimated by Argelander in the "Durch-

musterung." I offer this contribution, in an important and hitherto obscure branch of astronomy, to the scrutiny of persons competent to form an opinion.

So soon, however, as I had devised the method, it at once occurred to me that it was so simple that it must have been employed by other astronomers besides myself. Accordingly, I found that our old associate Mr. Dawes, whose memory is so greatly respected among us, did employ each of the means separately, by the combination of which I believe I have succeeded. My method, however, of applying and discussing these means will be found to be widely and generically different in principle from his, and especially because he has assumed as the basis of all his results, that a star observed to be only just visible in a telescope of which the diameter of the object glass is 0·15 inch, is of a certain definite and uniform magnitude—viz. the sixth; whereas, I have found, and I am sure other astronomers will find, that there is no constancy in the aperture at which any single star is just visible. The result of observations recently made in this Observatory, as will be seen in the results recorded in the present communication, is that on two different nights, when no differences of meteorological circumstances of the atmosphere were apparent, the same star shone with brilliancies differing by nearly a whole magnitude. Moreover, the effect of a difference of Zenith Distances from 52° to 74° on the same night, was found to affect the apparent brightness by six-tenths of a magnitude.

In referring thus to the methods employed by Mr. Dawes, I cannot pass over the still more ingenious device of Mr. Knobel (see *Monthly Notices*, Dec. 1874, and June 1875), who, by means of a glass mirror, in its two conditions of silvered and unsilvered, effected the same sort of results as those derived from my use of a glass wedge. Had Mr. Knobel seen fit to persevere to the end in forming a complete catalogue of star magnitudes, my own present efforts would have been assisted or modified. Still, it would have been interesting and valuable, if he had more fully recorded the resulting differences of the several individual determinations of the brightness of the same star, in order that the unavoidable errors arising from this (or any other) method might be distinctly seen. In what follows, I have for the most part endeavoured to give these details, my object being to discuss one method of observation, without forming any judgment as to other methods possibly quite as good.

Similar remarks apply to the memorable efforts detailed by Sir John Herschel in the Cape Observations (chap. iii. p. 305). It is perhaps needless to say that they bear the marks of his genius and sagacious perseverance, and cannot properly be disregarded in any stellar photometric researches.

The very successful efforts also of Messrs. Knott and Baxendell, printed so far back as 1863, show what can be done by eye-observations; but as they were not instrumentally photometric,

they scarcely fall within the species of methods discussed in this communication.

I will now detail my method of proceeding, and give the results of its application. A wedge of the purest and most homogeneous neutral-tinted glass that could be procured was carefully constructed for me by Mr. Grubb, of Dublin. It is about six inches long, and its greatest thickness one-tenth of an inch. To it is cemented another similar wedge of clear glass reversed, the whole forming a rectangular parallelopipedon. This wedge was provisionally divided, in its cell, to tenths of inches, and was made to slide close to the achromatic lens which formed the eyepiece of an excellent telescope of four inches aperture, attached to the tube of the large Equatoreal of this Observatory. Close on to this wedge, and immediately over the centre of the eye lens, projects a diaphragm, circularly perforated to direct the eye. Of course there is nothing new in this contrivance; its value depends on the mode of using it. A star, convenient for the purpose, was selected, presumed to be stable in its brightness: in this instance it was κ *Lyræ*, for which I shall assume the brightness or magnitude assigned to it by Argelander, 4·7; any other magnitude would serve the purpose perhaps equally well. This star was viewed on a fair night through the four-inch telescope, and the position of the wedge was noticed when the star was just extinguished. The mean of five readings consecutively taken was used in the further discussion. The aperture of the telescope was then reduced to two inches, and the reading of the wedge was taken as before, when the star became just invisible. It was contended that the effect of the thickness of wedge between the two readings produced the same effect as diminishing the aperture from four to two inches. This sort of observation repeated many times on different nights gives, as will be seen, an important constant, indicating the absorbing capacity of the wedge, of which constant great use is made in the following discussion. Thus if τ represent the thickness of the wedge through which the light passes, if L be the amount of the light incident, and L_1 the amount emergent, then

$$\log \frac{L}{L_1} = c\tau \text{ or } = \kappa I \qquad (1),$$

where I is the length of the interval between the two readings of the wedge, and $I = \tau \times$ tan angle of the wedge: κ is the constant to be determined.

Inasmuch as the star (κ *Lyræ*) is observed with apertures whose diameters are as 2 : 1, it follows that here

$$\log \frac{L}{L_1} = \log 4 = \kappa I;$$

therefore

$$\kappa = \frac{\cdot 6021}{I} \qquad (2).$$

This gives (κ) as a number expressed in terms of the number of intervals marked on the scale of the wedge, between the two observations. In the case of the wedge used in these researches (see Table I.)

$$\kappa = 0{\cdot}053 \pm 0{\cdot}0010 \qquad (3),$$

and therefore in general, from (1),

$$\log \frac{L}{L_l} = 0{\cdot}053\ I \qquad (4).$$

Again, if L_n and L_{n+x} represent the relative amounts of the light in two stars reputed to be of the n^{th} and of the $(n+x)^{th}$ magnitudes—that is, differing from each other by (x) magnitudes—then by the recognised convention, proposed by Mr. Pogson, and generally accepted, we have

$$\frac{L_n}{L_{n+x}} = (2{\cdot}512)^x$$

and therefore

$$\log \frac{L_n}{L_{n+x}} = {\cdot}4 \begin{pmatrix}\text{diff. of magnitude} \\ \text{of the two stars}\end{pmatrix} \qquad (5).$$

Now, suppose that I_x be the number of wedge intervals between the two readings of the wedge, at which the lights of these two stars are respectively extinguished when viewed successively through the wedge in the eyepiece of the four-inch telescope (or any other telescope), then by (4) we have

$$\log \frac{L_n}{L_{n+x}} = {\cdot}053\ I_x,$$

i.e. by (5) $\quad 0{\cdot}4$ (diff. of magnitude) $= 0{\cdot}053\ I_x$,

or $\quad$ difference of magnitude $= 0{\cdot}133\ I_x \qquad (6).$

This expression is the fundamental theorem on which the results in this research are based. Hence it becomes apparent, that, for the particular wedge used in these researches, one interval of the wedge (*i.e.* one-tenth of an inch) indicates a difference of about one-eighth of a magnitude; and as in practice, and in the average of five readings, less than one-half of an interval is practically cognisable in effect, it follows that the method may be relied upon to about ·06 of a magnitude. It appears also that if the original division of the wedge were provisional only, it would be practicable to make the divisions of such a length that each shall be the indication of one-tenth of a magnitude.

The following is an example of the manner in which one

value of κ is obtained, and also the difference of the magnitude between that star and another (Lal. 33612) :—

1881, *October* 17.

Name of star ...	κ Lyræ		κ Lyræ		Lal. 33612	
Aperture of telescope	4 inches.		2 inches.		4 inches.	
	Wedge Reading	Deviation from Mean.	Wedge Reading.	Deviation from Mean.	Wedge Reading.	Deviation from Mean.
	div.		div.		div.	
	19·9	0·34	32·1	0·54	31·1	0·46
	20·2	0·04	31·3	0·26	30·3	0·34
	20·4	0·16	31·4	0·16	30·4	0·24
	21·0	0·76	31·9	0·34	31·4	0·76
	19·7	0·54	31·1	0·46	30·0	0·64
Mean Reading	20·24	0·37	31·56	0·35	30·64	0·49

For κ, the Difference of Mean Readings $= 31{\cdot}56 - 20{\cdot}24 = 11{\cdot}32$; (div. div. div.)

therefore

by (2) ... ... $\kappa = \frac{0{\cdot}6021}{11{\cdot}32} = 0{\cdot}053$.

For Magnitude of Lalande 33612, the Difference of Mean Readings ... $= 30{\cdot}64 - 20{\cdot}24 = 10{\cdot}40$;

therefore

by (6) ... Diff. of Magnitude $= 10{\cdot}40 \times {\cdot}133 = 1{\cdot}38$ magnitude.

The numerical quantities given in equation (3) have been derived from the individual determinations exhibited in the following table.

Table I.

Date.	κ	Date.	κ
1881, Oct. 17	0·053	1881, Oct. 26	0·053
	·050	27	·050
18	·060		·041
	·056	29	·050
19	·060	Nov. 2	·058
	·061		·049
25	·051		

of which tabular values the mean is $\kappa = 0{\cdot}053$ with a probable error of 0·001.

From the observations made in the course of this investigation, it became apparent that on different nights κ *Lyræ*, and consequently other stars, shone with very considerable variations in brightness. For instance, on Oct. 17, the mean reading of the wedge when κ *Lyræ* was just extinguished was 20·24 divisions; on Oct. 18, 22·30 divisions; and on Oct. 26 it was 29·04

divisions—indicating an extreme difference of brightness, equivalent to one magnitude. At the same time, it is observable that the individual determinations of κ do not exhibit any such instability. This is very important. Independently of the general effect of meteorological circumstances, there was also perceptible an effect produced on the brightness of stars at different distances from the zenith, owing, no doubt, to the different thicknesses of the atmosphere through which the light necessarily passed. In order to ascertain whether it was possible to connect numerically this alteration of brightness with corresponding alterations of Zenith Distances, I constructed a table from which the ratio of the thickness of the atmosphere at any Zenith Distance (Z) to the thickness at the zenith itself could be obtained at sight. I assumed that the effect was approximately the same as that which would be produced by a homogeneous atmosphere of the height of $5\frac{1}{2}$ miles; but when I had completed it, I found that a similar table had already been constructed, and published in the "Annuaire de l'Observatoire de Montsouris," and reprinted in the "Edinburgh Observations," vol. xiv. The latter table is here subjoined; it seems to assume a height of atmosphere of 50 miles. It is perhaps curious to observe that for moderate altitudes either table may be used with equal advantage for approximate purposes.

Table II.

Zenith Distance.	Ratio of Thickness.	Zenith Distance.	Ratio of Thickness.	Zenith Distance.	Ratio of Thickness.
°		°		°	
1	1·00	31	1·17	61	2·02
2	1·00	32	1·18	62	2·09
3	1·00	33	1·19	63	2·15
4	1·00	34	1·20	64	2·23
5	1·01	35	1·22	65	2·30
6	1·01	36	1·23	66	2·39
7	1·01	37	1·25	67	2·48
8	1·01	38	1·26	68	2·58
9	1·02	39	1·28	69	2·68
10	1·02	40	1·30	70	2·80
11	1·02	41	1·32	71	2·93
12	1·03	42	1·34	72	3·07
13	1·03	43	1·36	73	3·22
14	1·03	44	1·38	74	3·39
15	1·04	45	1·41	75	3·58
16	1·04	46	1·43	76	3·79
17	1·05	47	1·46	77	4·02
18	1·05	48	1·49	78	4·29

Zenith Distance.	Ratio of Thickness.	Zenith Distance.	Ratio of Thickness.	Zenith Distance.	Ratio of Thickness.
19°	1·06	49°	1·51	79°	4·59
20	1·06	50	1·54	80	4·92
21	1·07	51	1·58	81	5·31
22	1·08	52	1·61	82	5·75
23	1·09	53	1·65	83	6·25
24	1·09	54	1·68	84	6·83
25	1·10	55	1·72	85	7·51
26	1·11	56	1·77	86	8·28
27	1·12	57	1·81	87	9·18
28	1·13	58	1·86	88	10·20
29	1·14	59	1·91	89	11·37
30	1·15	60	1·96	90	12·69

In order to obtain a formula for the atmospheric absorption of light at different Zenith Distances, I observe that by the notation of (1), we have, for the ratio of light incident in, and emergent from, the atmosphere

$$\log \frac{L}{L_1} = K \times (\text{thickness of the atmosphere traversed}); \qquad (7)$$

consequently, if L_n and L_{n+x} represent the measures of the light of κ *Lyræ* at the Zenith Distances (Z_1 and Z_2), and τ the difference of the tabular thickness at these Zenith Distances, then

$$\log \frac{L_n}{L_{n+x}} = K\tau, \qquad (8)$$

or from (5)

$$K\tau = \cdot 4 \text{ difference of magnitude.} \qquad (9)$$

Now, on Oct. 17 κ *Lyræ* was examined with the 4-inch telescope and wedge, at the Zenith Distance 36° 52′, and the light was extinguished at a wedge-reading of 20·14. It was again observed at the Zenith Distance 70° 58′, the corresponding wedge-reading being 22·64. This indicates a difference of magnitude of 0·33, also the tabular length of the path for a Zenith Distance 36° 52′ is 1·25, and for Zenith Distance 70° 58′ it is 2·93; consequently, the tabular difference of path is 1·68. Hence from (9)

$$\cdot 4 \times \cdot 33 = K\ 1 \cdot 68$$
$$K = 0 \cdot 079,$$

and

$$\log \frac{L_n}{L_{n+x}} = 0 \cdot 079\,\tau, \qquad (10)$$

and finally by (5)

$$\left.\begin{matrix}\text{Difference of magnitude}\\ \text{caused by atmosphere}\end{matrix}\right\} = 0{\cdot}198 \left\{\begin{matrix}\text{Tabular difference}\\ \text{of thickness}\end{matrix}\right. \qquad (11).$$

This again is the fundamental expression for the atmospheric effects on the light of a star arising from mere alteration in its Zenith Distance, *provided the meteorological elements remain the same.* For instance, *κ Lyræ* was on the same night observed again at the Zenith Distances 48° 37′ and 60° 22′. On applying the proper quantities taken from Table II., it appears that the theoretical alterations in magnitude due to the observation at these successive Zenith Distances were respectively 0·05, 0·09, and 0·19. The actual observed differences of magnitude were 0·05, 0·18, and 0·10 respectively; the error in the latter cases amounting to about one-tenth of a magnitude—*i.e.* if the effect of alterations of Zenith Distance were not considered, there would be an error in the stars of least altitude of 0·33 magnitude; but if the correction in (11) be applied, the resulting error will be at the worst one-tenth of a magnitude; and it will be observed that in this instance K is obtained from one observation only; and moreover what is here stated is to be regarded rather as the mere indication of a method than as its completion.

In Table III. are given the values of K which have been derived from the observations made at the greatest variation of Zenith Distance, and the comparison between the observed and computed magnitudes at intermediate altitudes.

Table III.

Date.	Star.	Z.D.	Thickness of Air.	Observed Diff. of Mag.	Value of K	Computed Diff. of Mag.	C−O
Oct. 17	*κ* Lyræ	36° 52′	1·25				
		48 37	1·50	0·05	0·079	0·05	0·00
		60 22	1·99	0·18		0·09	−0·09
		70 58	2·93	0·10		0·19	+0·09
18	*κ* Lyræ	52 12	1·61				
		61 48	2·08	0·20	0·151	0·17	−0·03
		71 59	3·07	0·35		0·38	−0·03
19	*κ* Lyræ	43 4	1·36				
		55 58	1·77	0·25	0·213	0·22	−0·03
		60 0	1·96	0·07		0·10	+0·03
25	*κ* Lyræ	52 38	1·64				
		58 13	1·88	0·15	0·139	0·09	−0·06
		73 43	3·34	0·44		0·50	+0·06
26	*κ* Lyræ	48 34	1·50				
		54 17	1·69	0·07	0·180	0·09	+0·02
		62 9	2·10	0·20		0·18	−0·02

From all these remarks combined it follows that it is not admissible to connect aperture with magnitude without taking into the account the general meteorological circumstances at the time of observation, and also any considerable variations of the Zenith Distance of the stars compared; but that if the wedge-reading of extinction of the standard star be observed from time to time—say, every hour—both these sources of errors will be effectually eliminated. Moreover, from the fifty stars (given in Table IV.) already compared, it seems that it may be safely assumed that the differences of magnitude are obtainable with a far greater degree of precision than can be reached by eye-estimation. Also, from the repeated observation of several of Argelander's fainter stars, on different evenings, as well as of the bright stars *α Lyræ*, *Capella* and *Aldebaran* (given in Table V.), it seems that the deviations from mean values are less than one-tenth of a magnitude.

Table IV.

No.	Star's Designation.	Oxford Mag. κ Lyræ = 4·7.	Argelander Mag.	Heis Mag.	Houzeau Mag.
1	Lal. 33612	6·08	5·8	6	
2	Groomb. 2530	6·28	6·0	6	6
3	Groomb. 2533	5·96	5·5	5·6	6
4	Groomb. 2538	6·14	6 0	6	6·7
5	Lal. 34064	6·90	7·0	6·7	
6	Lal. 34049	7·64	7·7		
7	μ Lyræ	5·31	5·1	5	5
8	Lal. 34132	6·08	6·1	6·5	
9	W. B. 18h No. 794	5·86	5·5	6·5	6
10	W. B. 18h No. 894	5·95	6·4	6	6·7
11	W. B. 18h No. 934	5·68	5·8	6	6
12	α Lyræ	0·53	1	1	1
13	W. B. 18h No. 972	6·30	7·0	6·7	
14	Radcliffe 3995	6·53	6·0	6·7	
15	Piazzi 18h No. 153	6·24	6·5	6·7	
16	W. B. 18h No. 1038	6·65	6·3	6·7	
17	Groomb. 2627	6·27	6·2	6·7	
18	W. B. 18h No. 1117	6·47	7·0	6·7	6·7
19	Lalande 34853	5·79	5·5	6	6
20	Piazzi 18h No. 172	6·21	6·4	6·7	
21	ε Lyræ	4·29	4·3	4·5	4
22	5 Lyræ	4·61	4·6	5·4	4
23	ζ2 Lyræ	5·46	5·5	4·5	4
24	ζ1 Lyræ	4·50	4·5		

No.	Star's Designation.	Oxford Mag. κ Lyræ = 4·7.	Argelander Mag.	Heis Mag.	Houzeau Mag.
25	W. B. 18^h No. 1218	5·07	4·9	5	
26	Groomb. 2664	5·77	6·0	6	6·7
27	Lalande 35045	6·07	6·0	6	
28	ν Lyræ	5·45	5·5	6·5	6
29	W. B. 18^h No. 1402	6·61	6·5	6·7	6·7
30	W. B. 18^h No. 1460	5·90	6·5	6	
31	W. B. 18^h No. 1489	5·84	6·2	6·7	6
32	δ^1 Lyræ	6·06	6·1	6	
33	δ^2 Lyræ	4·54	4·5	4·5	3·4
34	Bradley 2381	6·37	7·0	6·7	
35	Lal. 35405	7·07	7·5	6·7	
36	Lal. 35407	7·56	8·2		
37	Bradley 2388	5·51	6·7	6	6·7
38	W. B. 18^h 1641	5·98	6·2	6·5	6
39	γ Lyræ	3·18	3·2	3·4	3
40	W. B. 18^h 1670	5·74	5·8	6	5·6
41	Groomb. 2727	6·01	6·9	6	
42	Groomb. 2728	5·45	6·2	6	6·7
43	W. B. 19^h No. 20	6·06	6·3	6	6
44	17 Lyræ	5·42	6·0	6·5	6
45	ι Lyræ	4·90	5·2	5	5
46	Lal. 35922	6·38	6·5	6	
47	Lal. 35978	6·31	6·5		
48	Arg. + 26° No. 3474	6·48	7·4		
49	W. B. 19^h No. 159	6·60	7·5	6	
50	W. B. 19^h No. 165	6·67	7·7		

Notes.

No. 12. The magnitude given is the mean of four separate determinations: viz. 0·36, 0·65, 0·56 and 0·56.

No. 21. The magnitude is the mean of three separate determinations, the two components being treated as one star. The individual values are 4·20, 4·27 and 4·40.

No. 39. Three separate determinations gave the magnitude as 3·10, 3·13 and 3·31. The mean is here given.

The agreement is greater with Argelander, than with Heis or Houzeau.

TABLE V.

Name of Star.		Obs. Mag.	Obs. Mag.	Obs. Mag.	Obs. Mag.	Mean Mag.	Argelander's Mag.	Average Deviation from Mean.
α Lyræ		0·36	0·65	0·56	0·56	0·53		0·09
Capella		0·47	0·42	0·60		0·50		0·07
Aldebaran		0·88	0·86	0·93		0·90		0·03
Arg. +36° No.	3091	8·36	8·43	8·51		8·43	8·8	0·05
+36	3103	9·14	9·37			9·25	9·5	0·11
+36	3092	8·47	8·55	8·60		8·54	9·0	0·05
+36	3101	7·43	7·47	7·29		7·40	7·2	0·07
+36	3102	9·03	8·99			9·01	9·2	0·02
+36	3104	7·48	7·47	7·40		7·45	7·3	0·03
+36	3167	7·95	8·17	7·90		8·01	7·7	0·11
+36	3079	7·79		7·93		7·86	8·1	0·07

After the reading of the above communication to the Society, there ensued a long and interesting discussion by the Fellows present who had directed their attention to the subject.

Some doubts were expressed as to the facility, or even possibility, of the measurement of the magnitude being repeated (by the means proposed) by another observer, and with the same results, either identical or approximate. That question I have set at rest by causing certain stars to be observed by two persons. The position of extinction was not absolutely identical for both observers for the same star; but the wedge-interval between the positions of extinction for the two observers of the same star was practically the same; and this is all that is necessary, and all that can be expected in any photometric experiments, whether *nudis oculis* or with apparatus.

As an example, eight stars were observed by the two assistants, Mr. Plummer and Mr. Jenkins—the latter being comparatively new to the work—and the following are the results. It ought, however, to be premised that from the very nature of the observations there can be no previous bias on the part of the observer as to the precise position of extinction by the wedge.

No.	Star's Designation.	Observed Magnitude by P.	Observed Magnitude by J.	P.–J.
1	Lalande 33612 ...	6·05	6·08	−0·03
2	Groombridge 2530	6·10	6·02	+0·08
3	Groombridge 2533	5·92	5·77	+0·15
4	Groombridge 2538	6·03	6·16	−0·13
5	Lalande 34049 ...	7·66	7·69	−0·03
6	Lalande 34064 ...	6·84	6·90	−0·06
7	μ Lyræ	5·48	5·58	−0·10
8	W. B. xviii − 794	5·74	5·71	+0·03

The case now exhibited is the mean of five readings only; but the result, so far as it goes, shows that the two observers may possibly have a tendency to differ in their measures of light by one hundredth of a magnitude.

I have also had a further opportunity of comparing the results of three measurements of thirty out of the fifty stars referred to above. In my own opinion, they establish the exactitude of the method. As to its facility, it may be stated that during the very fine evening of the 17th inst. twenty stars were measured, each of them five times; but it would probably be better, and in the end more economical, to confine the work to about fifteen.

With regard to the homogeneity of the wedge, that element is sufficiently determined by the fact that the value of the constant κ remains sensibly persistent for all parts of the wedge; moreover, the observer's eye would necessarily detect any sensible inequality in its absorbing power, in the course of its continuous motion over the star in the focus of the eye-lens. As to what star or stars should be chosen for a standard, that is a matter to be determined hereafter; for my own purposes, I selected κ *Lyræ*, as a mere matter of convenience, for comparison with stars situated in its neighbourhood.

The practice of this Observatory will be to observe a set of stars on one fine night, taking for each the mean of five readings of the wedge. On the next fine night to repeat this same work twice, at an interval of about an hour; observing the standard star at least three times during the evening; and finally adopting the mean of the three sets as the magnitude of the star at the epoch of observation. Some months after it will be prudent to re-examine the whole with one set of five readings, by which process it may be expected that any variability in the stars will be indicated. As to an artificial standard of light, at present none seems to have been attained; it may be too much to say none is attainable. I subjoin a table of the thirty stars whose magnitudes have as yet been compared; the average deviation from the mean results is, so far, 0·08 magnitude.

Table VI.

Concluded Relative Magnitudes of Stars in the Constellation Lyra.

(Photometrically determined.)

Current No.	Star's Designation.	Observed Magnitude. 1	2	3	Mean Mag.	Average Deviation.	Magnitude in Argelander.	Heis.	Houzeau.
1	Lalande 33612	6·08	6·05	5·97	6·03	0·04	5·8	6	
2	Groombridge 2530	6·27	6·10	5·90	6·09	0·13	6·0	6	6
3	Groombridge 2533	5·96	5·92	5·90	5·93	0·02	5·5	5–6	6
4	Groombridge 2538	6·10	6·03	5·72	5·95	0·15	6·0	6	6–7
5	κ				4·7 adopted		4·7		

Current No.	Star's Designation.	Observed Magnitude. 1	2	3	Mean Mag.	Average Deviation.	Argelander.	Magnitude in Heis.	Houzeau.
6	Lalande 34049 ...	7·64	7·48	7·66	7·59	0·08	7·7	6–7	
7	Lalande 34064 ...	6·90	6·65	6·84	6·80	0·09	7·0		
8	μ Lyræ	5·31	5·48	5·34	5·38	0·07	5·1	5	5
9	Lalande 34132 ...	5·98	5·76	5·70	5·81	0·11	6·1	6–5	
10	W. B. xviii–794...	5·84	5·74	5·70	5·76	0·05	5·5	6–5	6
11	W. B. xviii–894...	5·95	6·00	5·82	5·92	0·07	6·4	6	6–7
12	W. B. xviii–934...	5·61	5·50	5·46	5·52	0·06	5·8	6	6
13	α Lyræ	0·36	0·36	0 42	0·38	0·03	1	1	1
14	W. B. xviii–972...*	6·01	6·36				7·0	6–7	
15	Radcliffe 3995 ...	6·51	6·32	6·31	6·38	0·09	6·0	6–7	6–7
16	Groombridge 2623	6·33	6·39	6·29	6·34	0·04	6·5	6–7	
17	W. B. xviii–1038...	6·64	6·85	6·70	6·73	0·07	6·3	6–7	
18	Groombridge 2627	6·21	6·17	6·30	6·23	0·05	6·2	6–7	
19	W. B. xviii–1117...	6·50	6·39	6·62	6·50	0·08	7·0	6–7	6–7
20	Lalande 34853 ...	5 79	6·00	5·98	5·92	0·09	5·5	6	6
21	Piazzi xviii–172...	6·15	6·35	6·32	6·27	0·10	6·4	6–7	
22	ϵ Lyræ	4·48	4·47	4·41	4·45	0·03	4·3	4–5	4
23	5 Lyræ	4·72	4·75	5·07	4·85	0·15	4·6	5–4	
24	W. B. xviii–1218	5·07	5·09	5·01	5·06	0·03	4·9	5	
25	Groombridge 2664	5·77	5·74	5·79	5·77	0·02	6·0	6	6–7
26	Lalande 35045 ...	6·07	6·01	5·92	6·00	0·05	6·0	6	
27	ν Lyræ	5·44	5·50	5·56	5·50	0·04	5·5	6–5	6
28	W. B. xviii–1402	6·61	6·43	6·36	6·47	0·10	6·5	6–7	6–7
29	W. B. xviii–1460	5·93	6·05	6·11	6·03	0·07	6·5	6	
30	W. B. xviii–1489	5·90	5·71	5·79	5·80	0·07	6·2	6–7	6

My present intention is to persevere in this research for some time to come, as being one which offers the promise of interesting results in many directions, and has been too long a desideratum in stellar astronomy. I propose, in particular, on the same principles and method, to systematically scrutinise the relative brilliancy at different parts of the Sun; employing for this purpose the De La Rue Reflector of 13 inches aperture, and provided with a Herschelian Prism in lieu of the smaller metallic plane mirror. Such observations, if continued long enough, may disclose important facts.

* This star was considered to be too near the horizon for accurate comparison at the time.

On the Spectra of Comets b and c, 1881, observed at the Royal Observatory, Greenwich.

(*Communicated by the Astronomer Royal.*)

Comet *b*, 1881.

1881, *June* 24, $8\frac{1}{2}^h$–$13\frac{1}{2}^h$.—The spectrum of Comet *b* was first examined on the evening of June 24, with the half-prism spectroscope mounted on the Great Equatoreal. The spectroscope was used in the "direct" position, as for the measures of displacement of lines in stellar spectra—*i.e.* with the light incident on that face of the "half-prism" which is perpendicular to the base. One half-prism was employed giving a dispersion of 18° from A to H, and a magnifying power of 14 was used on the viewing telescope. With this dispersion the spectrum from the nucleus and adjacent parts of the head appeared to be perfectly continuous, and only one band, in the green, was made out with certainty. This band was very distinct from one part of the head, but hardly traceable from any other part. Comparison with the second spectrum of carbon as given by alcohol vapour in a vacuum-tube showed that this band was situated at a distance of about 38 tenth-metres to the blue from the carbon-band at 5197 tenth-metres. Observer, W. C.

1881, *June* 25, $9\frac{1}{2}^h$–14^h.—With the spectroscope in the same position as on the previous evening, three bands were now detected in the Comet's spectrum, though the great brilliancy of the continuous spectrum nearly overpowered them, and rendered their observation a matter of difficulty. As far as could be judged, these bands were not obtained from the nucleus, but from its immediate vicinity. A comparison with the spectrum of cyanogen given by a vacuum-tube showed no instances of coincidence; but each of the three bands was seen to be coincident with the corresponding band of the spectrum of a Bunsen-flame at 5164, 4736, and 4311 respectively. No band was detected in the yellow. Observers, W. C. and M.

1881, *June* 29, 10^h–$14\frac{1}{2}^h$.—The bright bands had been isolated with such difficulty on June 24 and 25 that on this occasion the spectroscope was used as in the observations of prominences and reversed so as to give great purity of spectrum. The dispersion from A to H in this position is 5°, and the magnifying power 28. The continuous spectrum was given from a much smaller area of the Comet than on the two former nights of observations, being only 15″ to 18″ in breadth, and seen only over the nucleus and its immediate neighbourhood. Several dark lines were perceived in it, between the green and blue bands, one of these lines being undoubtedly F. The *b* lines could not be made out, but they would fall just within the bright edge of the green band.

Three bright bands were seen, yellow, green, and blue, the

band in the violet not being detected. Each band was bright and fairly sharp towards the red, and became gradually fainter towards the blue end of the spectrum. They were seen bright on the bright background of the continuous spectrum from the head, but could not be traced across the nucleus. The dark lines could not be detected in the spectrum of the nucleus, but this may have been due to its being so very narrow (2″ or 3″ in breadth).

The comparative brightness of the three bands was as follows :—

Yellow band	...	3	Edge not very sharp.
Green band	...	10	Edge sharp and distinct.
Blue band	...	1	Edge sharp.

The green band was obtained from the whole of the head, and for 12′ from the nucleus down the tail.

The single-prism spectroscope was now substituted for the other for a few minutes, and the exact coincidence of the three comet-bands with the three of the Bunsen-flame noticed, the accord when the two spectra were seen side by side being as perfect in every way as the eye could judge. This spectroscope did not show the violet band, but the blue band appeared much brighter in comparison with the other two than with the half-prism spectroscope. It was estimated as brighter than the yellow band, and as quite half as bright as the green.

No dark lines were distinguished in the continuous spectrum above the green band, but several strong lines were seen below it. Daylight came on before measures of these lines could be obtained, but rough estimations of their positions showed that two of the darkest were probably the E group, and the strong double line at 5327. The D lines were not made out with certainty. Observer, M.

The half-prism spectroscope reversed, with one half-prism, as in the earlier part of the evening of June 29 was used for all the subsequent observations both of this Comet and of Comet *c* (Schäberle's).

1881, *July* 2, 12^h.—The continuous spectrum was faint, and no dark lines were detected in it. The green band of the Comet was seen to be perfectly coincident with the band from the Bunsen-flame. Clouds prevented further observation. Observer, M.

1881, *July* 4, 10^h–14^h.—The three bands, yellow, green and blue, were seen as usual, the first and last being very faint. No others were detected. The continuous spectrum was too narrow to show any dark lines. Observer, M.

1881, *July* 6, 10^h–14^h.—The continuous spectrum was more distinct than on July 4, but no dark lines could be detected.

With the spectra of the Comet and of the Bunsen-flame

arranged one above the other, and the flame adjusted until the bright sharp edge of the green band was of the same intensity in each, the resemblance between the two spectra was exceedingly striking, the three principal bands corresponding exactly in position, in brightness, and in the manner and degree in which they shaded off towards the violet. The fourth band (that in the violet) was, however, far less distinct in the Comet spectrum than in that of the Bunsen-flame—indeed, its presence in the former was only just suspected. Search was also made for a red band and with a very wide slit an extremely faint light was just suspected somewhere in the red part of the spectrum about midway between C and D. Observer, M.

The following are the determinations of the wave-lengths of the less refrangible edges of the three principal bands.

Yellow Band.

Date.	Observer.	Spectroscope.	Compared with	Width of Slit.	Wave-Length of Comet-band.
				tenth-metr.	tenth-metr.
June 29	M.	Half prism, reversed	Marsh gas	13·1	5627·0
		,, ,,	,,	13·1	39·5
		,, ,,	,,	13·1	19·4
July 6	M.	,, ,,	Bunsen-flame	16·8	32·4
		,, ,,	,,	16·8	29·5
		,, ,,	,,	16·8	29·9
		,, ,,	,,	16·8	35·0
			MEAN	5630·4 ± 1·6	

Green Band.

June 24	W. C.	Half prism, direct	Alcohol	62·1	5151·7*
		,, ,,	,,	62·1	59·8
25	M.	,, ,,	Cyanogen	9·7	67·9
		,, ,,	,,	9·7	59·0
		,, ,,	,,	9·7	61·5
29	M.	Half prism, reversed	Marsh gas	9·6	59·9
		,, ,,	,,	9·6	61·8
		,, ,,	,,	9 6	60·9
		Single prism	Bunsen-flame	26·1	61·5
		,,	,,	26·1	65·0
July 4	M.	Half prism, reversed	,,	14·7	65·3
		,, ,,	,,	14·7	63·7
		,, ,,	,,	5·4	58·1
		,, ,,	,,	5·4	61·9
		,, ,,	,,	5·4	65·0

* Measure rough.

Date.	Observer.	Spectroscope.	Compared with	Width of Slit.	Wave-Length of Comet-band.
				tenth-metr.	tenth-metr.
July 6	M.	Half prism, reversed	Bunsen-flame	3·6	63·8
		,, ,,	,,	3·6	64·0
		,, ,,	,,	3·6	64·0
		,, ,,	,,	3·6	64·3
		,, ,,	,,	3·6	64·0
		,, ,,	,,	3·6	65·3
		,, ,,	,,	12·4	64·0
		,, ,,	,,	12·4	63·7
		,, ,,	,,	12·4	63·4
		,, ,,	,,	12·4	65·2
		,, ,,	,,	12·4	64·4
			MEAN	5162·7 ± 0·4	
		Blue Band.			
June 29	M.	Half prism, reversed	Marsh gas	6·2	4728·2
		,, ,,	,,	6·2	30·2
July 6	M.	,, ,,	Bunsen-flame	7·9	35·5
		,, ,,	,,	7·9	36·9
		,, ,,	,,	7·9	36·0
		,, ,,	,,	7·9	36·4
			MEAN	4733·9 ± 1·1	

The following measures were also obtained of the dark line F seen in the continuous spectrum as compared with the Hβ line from a vacuum-tube.

Date	Observer.	Spectroscope.	Width of Slit.	Wave-Length of Dark Line.	Apparent Displacement.
			tenth-metr.	tenth-metr.	tenth-metr.
June 29	M.	Half prism, reversed	2·8	4860·92	+0·18
		,, ,,	2·8	60·42	−0·32

Thalén's wave-lengths for the less refrangible edges of the bands in the two spectra of the carbon compounds were assumed throughout, as follows :—

Band.	First Spectrum. Bunsen-flame.	Second Spectrum. Marsh Gas or Cyanogen.
	tenth-metr.	tenth-metr.
Yellow band	5633·0	5607·5
Green band	5164·0	5197·0
Blue band	4736·0	4697·0

Comet *c* 1881 (Schäberle's).

1881, *Aug.* 4, $8\frac{1}{2}^h$–$13\frac{1}{2}^h$.—The Comet showed a spectrum consisting of three bright bands approximately coincident with the

three brightest bands of the spectrum of the Bunsen-flame. Eventually a very faint continuous spectrum, due to the nucleus, was detected. The green band was the only one which had a sufficiently defined edge to be measured. The yellow band appeared to be displaced towards the blue of the corresponding band of the flame spectrum by a small but unmistakeable distance—say about 8 tenth-metres. The blue band was too faint for anything to be observed concerning it further than that it showed a rough coincidence with the band from the Bunsen-flame. The whole of the head of the Comet gave the spectrum of the bands.

The relative brightness of the bands appeared to be as follows:—

Yellow band	3
Green band	10
Blue band	1

Observer, M.

1881, *Aug.* 6, $8\frac{1}{2}^h$–13^h.—The Comet's spectrum showed no change since August 4, except that it now seemed very faint. owing to the brilliant moonlight. The nucleus still gave a faint continuous spectrum, traceable from about D to F, but the spectrum of the bands was many times as bright. The whole of the head of the Comet gave the green band, but it could not be detected over the tail. The blue band was seen, but was not measurable, and no new bands could be discerned in the red, orange or violet. A narrow slit was employed on the green band, but it could not be resolved into lines. Observer, M.

1881, *Aug.* 19, 8^h–$11\frac{1}{2}^h$.—The three bands were seen as on the two previous occasions, and with a very wide slit two others were suspected, the one as far below D as the yellow band is above it—that is to say, in the neighbourhood of wave-length 6200± tenth-metres—and the other just to the red of G or at wave-length 4310±. The continuous spectrum was now obtained not merely from the nucleus, but also from its immediate neighbourhood, and showed a total breadth of 7″, and it was visible from the red band up to the one in the violet, but no dark lines could be detected in it. The band spectrum was, however, still many times as bright as the continuous spectrum from the nucleus, at the less refrangible edges of the principal bands. The green band was given by every part of the head, even the faintest, and was clearly obtained from the tail for quite 10′ from the nucleus. A very narrow slit was used on the green band in order to detect any resolvability if possible. The band could not be broken up into lines, but a second edge was suspected about 5126. Observer, M.

The following measures were obtained of the positions of the less refrangible edges of the yellow and green bands. Of the

blue band it was only ascertained that it seemed to be coincident with the band of the Bunsen-flame at 4736·0. The half-prism spectroscope reversed was used throughout, and the comparisons were all made with the spectrum of a Bunsen-flame.

Yellow Band.

Date.	Observer.	Width of Slit.	Wave Length Comet Band.
		tenth-metres.	tenth-metres.
1881, August 6	M.	33·9	5629·3
		33·9	36·3
		33·9	21·3
		33·9	33·9
		33·9	24·7
		Mean	5629·1 ± 2·1

Green Band.

1881, August 4	M.	15·6	5162·8
		15·6	63·0
		15·6	63·3
		15·6	64·4
		6·3	65·7
		6·3	63·9
		6·3	62·8
		6·3	61·8
		6·3	64·3
		6·3	63·1
August 6	M.	6·4	62·6
		6·4	63·1
		6·4	63·3
		6·4	64·4
		6·4	64·5
		6·4	62·8
		6·4	64·0
		6·4	65·1
		6·4	63·4
		6·4	63·6
		Mean	5163·6 ± 0·15

The initials W. C. and M. are those of Mr. Christie and Mr. Maunder respectively.

Royal Observatory, Greenwich:
1881, *November* 10.

On the North Polar Distances of the Cape Catalogue for 1880, *and on the Greenwich and Cape Mean Systems of North Polar Distances.* By A. M. W. Downing, M.A.

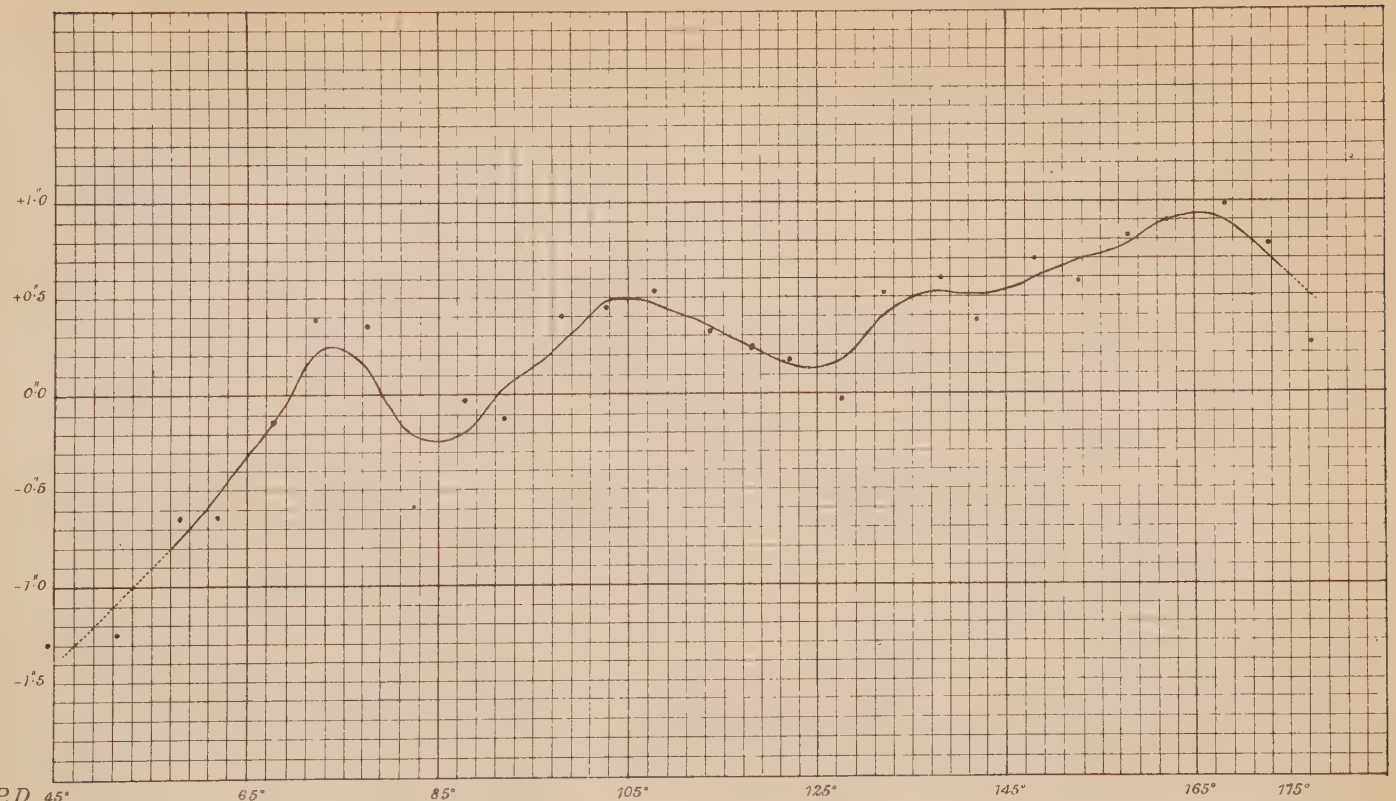
The chief difficulty to be encountered in discussing the North Polar Distances of the Cape Catalogue for 1880 is the uncertainty in the values of the proper motions of the great mass of southern stars. It is on this account that I have selected for comparison with this catalogue the Melbourne Catalogue for 1870, as being nearest in date of any southern catalogue. There are 911 stars common to the catalogues which are available for the comparison, and it is reasonable to suppose that when such a large number of stars is used the results will be sensibly free from error arising from the assumption of erroneous proper motions.

The assumed proper motions have been taken from the Cape Catalogue itself, or from the list of additional proper motions given at the end of the catalogue, or from the Melbourne Catalogue, or from the Cape Catalogues for 1860 or 1840; but a large number of the stars have necessarily been used with assumed proper motion=0. In order to show that this proceeding has not had an appreciable effect on the computed differences between the N.P.D.'s of the catalogues, when taken in groups extending over 5° of N.P.D., I have given the probable errors of a difference between the catalogue places for each group; and it appears that there is no decided increase in these probable errors in passing from stars which are observable in the northern hemisphere, and whose proper motions are known with comparative certainty, to the stars which are situated beyond the reach of northern observers.

Only one star out of the whole number has been rejected for discordance. This is Lacaille 4342, which is No. 5595 in the Cape Catalogue and No. 511 in the Melbourne Catalogue, but its place (as far as I know) is not given in any other catalogue. The difference Cape *minus* Melbourne amounts to $+4''{\cdot}69$, and as its N.P.D. in each catalogue depends on a considerable number of observations, and the mean dates of observation in the Cape and Melbourne Catalogues are 1871·5 and 1868·7 respectively, it is reasonable to suppose that this star has a large proper motion in N.P.D. In fact, Lacaille's place compared with that in the Cape Catalogue gives for proper motion $+0''{\cdot}8$. I commend this star to the attention of H.M. Astronomer at the Cape.

The places in the Cape Catalogue have been brought back to 1870, and the differences Cape *minus* Melbourne taken. The differences have then been combined in groups of 5°, and the means of each group and the mean N.P.D. of each group found. These mean differences have been laid down as points on cross-ruled paper, and a curve (*see* diagram) drawn through them, which may be taken to represent the systematic differences between the N.P.D.'s of the catalogues.

Comparison of the North Polar Distances of the Cape (1880) and Melbourne (1870) Catalogues.



Spottiswoode & Co. Lith. London.

The following table gives the differences, corresponding to the mean N.P.D. of each group, as computed and as read off from the curve. The column under ϵ_1 is the probable error of a single difference between the positions as given in the catalogues, and is found from the discordance of each separate difference from the mean of the group. There are not a sufficient number of observations of stars north of N.P.D. 60° in the Cape Catalogue (such observations being of course foreign to the plan of the work) to enable us to determine with any accuracy the systematic differences betwen the catalogues, for stars situated near the northern horizon of the Observatories :—

N.P.D.	Number of Stars.	Cape—Melbourne Means.	ϵ_1	Cape—Melbourne Curve.
° ′		″	″	″
44 38	2	−1·30	—	—
51 11	2	−1·25	—	—
57 41	4	−0·63	—	—
62 4	8	−0·64	±0·46	−0·51
67 57	9	−0·12	·54	−0·12
72 6	8	+0·39	·32	+0·21
77 3	12	+0·36	·56	+0·13
82 31	15	−0·60	·59	−0·22
87 34	11	−0·03	·38	−0·20
91 45	14	−0·12	·49	+0·03
97 59	7	+0·40	·32	+0·27
102 42	7	+0·45	·30	+0·47
107 27	11	+0·54	·42	+0·47
113 15	10	+0·32	·35	+0·36
117 28	37	+0·26	·50	+0·26
122 21	38	+0·18	·62	+0·15
127 32	65	−0·02	·54	+0·17
132 7	71	+0·52	·60	+0·41
137 25	61	+0·60	·49	+0·53
141 48	32	+0·38	·44	+0·52
147 59	46	+0·70	·46	+0·60
152 31	208	+0·59	·49	+0·68
157 46	130	+0·82	·52	+0·78
161 57	18	+0·91	·52	+0·91
168 8	29	+0·99	·56	+0·92
172 39	41	+0·78	·39	+0·72
177 1	15	+0·26	·23	—

The average probable error of a difference between the N.P.D.'s of the catalogues is ±0″·46. From a comparison of the Green-

wich (1864) and Melbourne (1870) Catalogues (*Vierteljahrsschrift*, Bd. xi. S. 187) Prof. Gyldén found the probable error of a difference between the N.P.D.'s of these Catalogues, for stars situated in the zone 60°—110° N.P.D., to be $\pm 0''.30$. The larger probable error found above can hardly be attributed to the use of inaccurate proper motions, for confining ourselves to stars situated between 60° and 110° N.P.D., the average probable error of a difference is $\pm 0''.44$. It would appear, therefore, that the probable accidental errors of the N.P.D.'s of the Cape Catalogue for 1880 are somewhat larger than those of the Greenwich Catalogue for 1864.

By reading off from the curve given above the differences corresponding to every 4° of N.P.D., and making use of the comparisons given in my papers in the *Monthly Notices* for December 1878, January 1879, and January 1881, we get the following corrections applicable to the N.P.D.'s of the several catalogues named to reduce them to the system of the Cape Catalogue for 1880; except that for the Cape Catalogue (1833) the *data* in Mr. Boss's *Declinations of Fixed Stars* have been used from N.P.D. 60° to N.P.D. 120° inclusive.

N.P.D.	Cape (1833).	Cape (1840).	Cape (1860).	Melbourne (1870).	Greenwich Mean System.
60°	−0″·88	+0″·08	−0″·30	−0″·65	−0″·71
64	−0·96	−0·10	−0·35	−0·40	−0·74
68	−0·78	−0·08	−0·21	−0 11	−0·59
72	−0·35	+0·25	+0·08	+0·20	−0·31
76	−0·13	+0·14	+0·13	+0·19	−0·23
80	−0·17	−0·33	−0·05	−0·08	−0·37
84	−0·27	−0·89	−0·20	−0·24	−0·51
88	−0·44	−1·32	−0·36	−0·19	−0·72
92	−0·26	−1·19	−0·11	+0·03	−0·51
96	−0·26	−1·08	0·00	+0·17	−0·45
100	−0·27	−0·84	+0·15	+0·35	−0·30
104	−0·39	−0·48	+0 22	+0·49	−0·13
108	−0·57	−0·09	+0·21	+0·47	+0 01
112	−0·81	+0·03	+0·10	+0·40	+0·07
116	−1·11	−0·30	−0·14	+0·29	−0·10
120	−1·22	−0·56	−0·27	+0·19	−0·12
122	−1·51	−0·60	−0·28	+0·16	+0 05
124	−1·40	−0·50	−0·23	+0·14	−0·54
128	−1·06	−0·19	−0·10	+0·18	
132	−0·59	+0·05	−0·06	+0·41	
136	−0·32	+0·08	−0·21	+0·51	
140	−0·03	+0·23	−0·18	+0·52	

N.P.D.	Cape (1833).	Cape (1840).	Cape (1860).	Melbourne (1870).	Greenwich Mean System.
144°	−0″·18	+0″·21	−0″·23	+0″·53	
148	+0·09	+0·38	−0·09	+0·60	
152	+0·61	+0·77	+0·17	+0·67	
156	+0·76	+1·11	+0·30	+0·74	
160	+0·75	+1·25	+0·43	+0·84	
164	+0·95	+1·29	+0·59	+0·93	
168	+1·11	+1·06	+0·64	+0·91	
172	+0·99	+0·69	+0·56	+0·75	
176	+0·75	+0·59	+0·45	+0·57	

The Greenwich "Mean System" is found by taking the simple mean of the comparisons of six Greenwich Catalogues with the Melbourne Catalogue given by the Astronomer Royal on page 172 of vol. xlv. of the *Memoirs*, Besssel's refractions with Main's corrections below Z.D. 82° being used in all cases.

The above comparison with the Cape Catalogue for 1860 is very satisfactory, showing as it does that the systematic errors of the catalogues do not differ by any considerable amount, except perhaps for the circumpolar stars. It will be remembered that the south latitude of the Observatory adopted in the several catalogues was, for the 1833 Catalogue 33° 56′ 3″·20, for the 1840 Catalogue 33° 56′ 3″·25, for the 1860 Catalogue 33° 56′ 3″·56, and for the 1880 Catalogue 33° 56′ 3″·41. The refractions used were those of Bessel's *Tabulæ Regiomontanæ*, except that for the period during which the observations included in the last-mentioned catalogue were made it was found that the thermometer read 0°·55 too high, so that Bessel's mean refractions were really diminished in the proportion 0·9988 : 1. I can find no information with regard to the errors of the thermometer for the periods corresponding to the other catalogues.

The following table gives the corrections applicable to the approximation to a Mean System formed from the Cape Catalogues for 1840, 1860, and 1880, to reduce them to the Greenwich Mean System as given above:—

N.P.D.	Greenwich − Cape.	N.P.D.	Greenwich − Cape.
60°	+0″·64	96°	+0″·09
64	+0·59	100	+0·06
68	+0·49	104	+0·04
72	+0·42	108	+0·03
76	+0·32	112	−0·03
80	+0·24	116	−0·05
84	+0·15	120	−0·17
88	+0·13	122	−0·34
92	+0·08	124	+0·30

This, in common with my previous comparisons of Greenwich and Cape results, seems to indicate that there is a systematic error affecting the Cape N.P.D.'s near the north horizon, and increasing as we approach the horizon (probably the effect of uncorrected flexure), which makes the observed Z.D.'s too large. A definite decision on this point cannot, however, be arrived at with the materials at present at our disposal. But much light will be thrown on the subject by the publication of a limited fundamental catalogue, in which special attention is paid to such points as latitude, refraction, flexure, and discordance of direct and reflexion observations. I understand that the staff of the Cape Observatory are now employed on the observations necessary for the formation of such a catalogue.

The residuals given above, when laid down as points on cross-ruled paper, so nearly lie on a right line that from N.P.D. 60° to 120° they may be closely represented by the expression

$$+0''.20 \sin \text{N.P.D.} + 0''.675 \cos \text{N.P.D.} \qquad \text{(I.)}$$

If, however, it be assumed that the residuals between N.P.D. 60° and 112° arise from errors in the Cape Z.D.'s they may be very fairly represented by

$$+0''.74 \sin \text{Z.D.} - 0''.26 \cos \text{Z.D.} \qquad \text{(II.)}$$

as will be seen from the following tabular statement :—

N.P.D.	Greenwich − Cape. Formula (I.).	Formula (II.).	Excess of Formula (I.).	Formula (II.).
60°	+0″.51	+0″.55	−0″.13	−0″.09
64	·48	·51	·11	·08
68	·44	·47	·05	− ·02
72	·40	·42	− ·02	·00
76	·36	·38	+ ·04	+ ·06
80	·31	·32	·07	·08
84	·27	·28	·12	·13
88	·22	·23	·09	·10
92	·18	·17	·10	·09
96	·13	·12	·04	+ ·03
100	·08	·06	+ ·02	·00
104	+ ·03	+ ·01	− ·01	− ·03
108	− ·02	− ·05	·05	·08
112	·07	− ·10	·04	− ·07
116	·10	—	− ·05	—
120	− ·17	—	·00	—

The last two columns give the differences of the residuals found from each of the formulæ and from the means of the catalogue comparisons given in the previous table.

With the exception of the discordance referred to above, the close agreement between the N.P.D.'s found from the Greenwich and Cape observations is very remarkable.

1881, *November* 5.

Ephemeris for finding the Positions of the Satellites of Uranus, 1882.

By A. Marth, Esq.

In October the Earth has passed through the planes of the orbits of the satellites of *Uranus* from the side on which it had been since 1840 to the other side, on which the satellites appear to move in the direction of *in*creasing position-angles, and on which, after returning next spring for some months to the former side, it will remain till the year 1923. In view of the importance of securing series of observations of the satellites during the present apparition of the planet, the ephemeris is made to begin a month earlier than would otherwise be necessary.

The angle of position p_0 of the major axes, the major and minor semiaxes a and b of the apparent ellipses described by the satellites, and the latitude of the Earth above the assumed plane of their orbits, are the following:—

Greenwich Noon.		*Ariel.*		*Umbriel.*		*Titania.*		*Oberon.*		Lat. of Earth.
1881.	p_0	a_1	b_1	a_2	b_2	a_3	b_3	a_4	b_4	
	°	″	″	″	″	″	″	″	″	°
Dec. 10	15·24	14·52	+0·67	20·22	+0·94	33·17	+1·53	44·35	+2·05	+2·65
20	15·25	14·63	0·70	20·37	0·97	33·42	1·59	44·69	2·13	2·73
30	15·25	14·76	0·70	20·56	0·98	33·73	1·60	45·11	2·14	2·72
1882.										
Jan. 9	15·24	14·89	+0·68	20·74	+0·95	34·02	+1·55	45·50	+2·07	+2·61
19	15·22	15·01	0·63	20·91	0·88	34·30	1·45	45 86	1·93	2·42
29	15·20	15·11	0·57	21·05	0·79	34·53	1·29	46·18	1·73	2·15
Feb. 8	15·17	15·19	0·48	21·17	0·67	34·72	1·10	46·43	1·47	1·81
18	15·14	15·25	0·38	21·25	0·53	34·86	0·87	46·61	1·16	1·42
28	15·10	15·29	0·27	21·30	0·37	34·93	0·61	46·72	0·82	1·00
Mar. 10	15·06	15·29	0·15	21·31	0·21	34·95	0·35	46·74	0·47	0·57
20	15·01	15·27	+0·04	21·28	+0·06	34·90	+0·09	46·68	+0·12	+0·15
30	14·97	15·23	−0 07	21·21	−0·09	34·80	−0·15	46·53	−0·21	−0·25
Apr. 9	14·93	15·16	0·16	21·12	0·23	34·64	0·37	46·32	0·50	0·61
19	14·90	15·07	0·24	20·99	0·34	34·43	0·55	46·04	0·74	0·92
29	14·88	14·96	0·30	20 84	0·42	34·18	0·69	45·71	0·92	1·15
May 9	14·86	14·84	0·34	20·67	0·47	33·91	0·77	45·35	1·03	1·31
19	14·85	14·71	0·35	20·49	0·49	33·61	0·80	44 95	1·07	1·38
29	14·85	14·58	−0·35	20·31	−0·48	33·31	−0·79	44·55	−1·06	−1·36

Longitudes of the satellites in their orbits reckoned from the points where they are at their greatest northern elongations :—

	Ariel.		*Umbriel.*		*Titania.*		*Oberon.*	
Greenwich Noon.	Long.	Diff.	Long.	Diff.	Long.	Diff.	Long.	Diff.
1881.	°	°	°	°	°	°	°	°
Dec. 10	258·38	1428·47	160·09	868·76	188·35	413·55	327·70	267·42
20	246·85	·47	308·85	·76	241·90	·54	235·12	·41
30	235·32	·47	97·61	·75	295·44	·53	142·53	·40
1882.								
Jan. 9	223·79	·44	246·36	·72	348·97	·51	49·93	·38
19	212·23	·41	35·08	·71	42·48	·50	317·31	·37
29	200·64	·38	183·79	·68	95·98	·49	224·68	·36
Feb. 8	189·02	·35	332·47	·67	149·47	·47	132·04	·35
18	177·37	·33	121·14	·65	202·94	·46	39·39	·33
28	165·70	·30	269·79	·63	256·40	·46	306·72	·34
Mar. 10	154·00	·28	58·42	·62	309·86	·45	214·06	·34
20	142·28	·26	207·04	·61	3·31	·45	121·40	·33
30	130·54	·24	355·65	·60	56·76	·44	28·73	·34
Apr. 9	118·78	·23	144·25	·60	110·20	·45	296·07	·34
19	107·01	·23	292·85	·60	163·65	·46	203·41	·35
29	95·24	·22	81·45	·60	217·11	·47	110·76	·35
May 9	83·46	·22	230·05	·61	270·58	·47	18·11	·37
19	71·68	1428·21	18·66	868·61	324·05	413·48	285·48	267·38
29	59·89		167·27		17·53		192·86	

These values are to be interpolated for the times for which the positions of the satellites are required. The position-angles p and distances s are then to be found by means of the formulæ :—

$$s \sin (p - p_0) = b \sin \text{long.}$$
$$s \cos (p - p_0) = a \cos \text{long.}$$

The satellites move in the direction of *in*creasing position-angles when b is positive, and in the direction of *de*creasing position-angles when b is negative, and will be at their greatest elongations ("N" in posit. p_0 and "S" in posit. $p_0 + 180°$), and at their superior and inferior conjunctions with the planet at or about the following hours, Greenwich mean time :—

Ariel.

	N.		S.			N.		S.			N.		S.	
1881.	d	h	d	h	1882.	d	h	d	h	1882.	h	h	d	h
Dec.	10	17·1	11	23·3	Feb.	4	3·8	5	10·0	April	3	3·1	4	9·3
	13	5·6	14	11·8		6	16·2	7	22·5		5	15·5	6	21·8
	15	18·0	17	0·3		9	4·7	10	11·0		8	4·0	9	10·3
	18	6·5	19	12·8		11	17·2	12	23·5		10	16·5	11	22·8
	20	19·0	22	1·3		14	5 7	15	12·0		13	5·0	14	11·3
	23	7·5	24	13·7		16	18·2	18	0·4		15	17·5	16	23·8
	25	20·0	27	2·2		19	6·7	20	12·9		18	6·0	19	12·3
	28	8·5	29	14·7		21	19·2	23	1·4		20	18·5	22	0 8
	30	21·0				24	7·7	25	13·9		23	7 0	24	13·3
1882.		Jan.	1	3·2		26	20·2	28	2·4		25	19·5	27	1·8
Jan.	2	9·4	3	15·7	Mar.	1	8·7	2	14·9		28	8·0	29	14·3
	4	21·9	6	4·2		3	21·1	5	3·4		30	20·5	M. 2	2·7
	7	10·4	8	16 6		6	9 7	7	15·9	May	3	9·0	4	15·2
	9	22·9	11	5·1		8	22·1	10	4·4		5	21·5	7	3·7
	12	11·4	13	17·6		11	10·6	12	16·9		8	10·0	9	16·2
	14	23·9	16	6·1		13	23·1	15	5·4		10	22·5	12	4·7
	17	12·3	18	8·6		16	11·6	17	17·8		13	11·0	14	17·2
	20	0·8	21	7·1		19	0·1	20	6·3		15	23·5	17	5·7
	22	13·3	23	19·6		21	12 6	22	18·8		18	12·0	19	18·2
	25	1·8	26	8·0		24	1·1	25	7·3		21	0·4	22	6·7
	27	14·3	28	20·5		26	13·6	27	19·8		23	12·9	24	19·2
	30	2·8	31	9·0		29	2·1	30	8·3		26	1·4	27	7·7
Feb.	1	15·3	2	21·5		31	14·6	A. 1	20·8		28	13·9	29	20·2

Umbriel.

	N.		S.			N.		S.			N.		S.	
1881.	d	h	d	h		d	h	d	h		d	h	d	h
Dec.	12	7·2	14	9·0	Feb.	4	4·2	6	5·9	Apr.	3	4·7	5	6·4
	16	10·7	18	12·4		8	7·6	10	9·3		7	8·1	9	9·9
	20	14·1	22	15·9		12	11·1	14	12·8		11	11·6	13	13·3
	24	17·6	26	19·3		16	14·5	18	16·3		15	15·1	17	16·8
	28	21·0	30	22·8		20	18·0	22	19·7		19	18·6	21	20·3
1882.						24	21·5	26	23·2		23	22·0	25	23·8
Jan.	2	0·5	4	2·2	Mar.	1	0·9	3	2·7		28	1·5	30	3·2
	6	3·9	8	5·7		5	4·4	7	6·1	May	2	5·0	4	6·7
	10	7·4	12	9·3		9	7·9	11	9·6		6	8·4	8	10·2
	14	10·9	16	12·6		13	11·3	15	13·1		10	11·9	12	13·6
	18	14·3	20	16·0		17	14·8	19	16·5		14	15·4	16	17·1
	22	17·8	24	19 5		21	18·3	23	20·0		18	18·8	20	20·6
	26	21·2	28	23·0		25	21·7	27	23·5		22	22·3	25	0·0
	31	0·7	F. 2	2·4		30	1·0	A. 1	2·9		27	1·8	29	3·5

Titania.

	N. elong.		Inf. Conj.		S. elong.		Sup. Conj.	
		h		h		h		h
1881.	—		—		Dec. 9	19·2	Dec. 11	23·4
Dec. 14	3·6		Dec. 16	7·8	18	12·1	20	16·3
22	20·5		25	0·8	27	5·0	29	9·2
31	13·5							
1882.			Jan. 2	17·7	Jan. 4	21·9	Jan. 7	2·2
Jan. 9	6·4		11	10·6	13	14·9	15	19·1
17	23·2		20	3·6	22	7·8	24	12·1
26	16·3		28	20·5	31	0·8	Feb. 2	5·0
Feb. 4	9·2		Feb. 6	13·5	Feb. 8	17·7	10	22·0
13	2·2		15	6·4	17	10·7	19	14·9
21	19·2		23	23·4	26	3·7	28	7·9
March 2	12·1		March 4	16·4	March 6	20·6	March 9	0·9
11	5·1		13	9·3	15	13·6	17	17·8
19	22·1		22	2·3	24	6·6	26	10·8
28	15·1		30	19·3	April 1	23·5	April 4	3·8
April 6	8·0		April 8	12·3	10	16·5	12	20·8
15	1·0		17	5·2	19	9·5	21	13·7
23	18·0		25	22·2	28	2·5	30	6·7
May 2	10·9		May 4	15·2	May 6	19·4	May 8	23·7
11	3·9		13	8·2	15	12·4	17	16·6
19	20·9		22	1·1	24	5·3	26	7·6
28	13·8							

Oberon.

	N. elong.		Inf. Conj.		S. elong.		Sup. Conj.	
		h		h		h		h
1881.								
Dec. 11	5·0		Dec. 14	13·8	Dec. 17	22·5	Dec. 21	7 3
24	16·1		28	0·9	31	9·6		
1882.							Jan. 3	18·4
Jan. 7	3·2		Jan. 10	12·0	Jan. 13	20·8	17	5·5
20	14·3		23	23·1	27	7·9	30	16·7
Feb. 3	1·5		Feb. 6	10·3	Feb. 9	19·1	Feb. 13	3·8
16	12·6		19	21·4	23	6·2	26	15·0
March 1	23·8		March 5	8·6	March 8	17·4	Mar. 12	2·2
15	11·0		18	19·8	22	4·6	25	13·4
28	22·2		April 1	7·0	April 4	15·8	April 8	0·6
April 11	9·4		14	18·2	18	3·0	21	11·8
24	20·6		28	5·4	May 1	14·2	May 4	23·0
May 8	7·7		May 11	16·5	15	1·3	18	10·1
21	18·9		25	3·7	28	12·5		

During the period of 170 days, over which the Ephemeris extends, there will be some 230 occasions when two of the satellites pass one another at a short distance. As I have not learnt how close to the planet the satellites can be seen with some of the most powerful modern telescopes, I have not altered the limits adopted last January * for excluding the conjunctions which do not offer some fair prospect of being observable in Europe or America. I give now for the others a list similar to that printed on pp. 155 and 156, containing the computed position-angles and distances of the satellites which pass one another, for the nearest preceding and following even hour, Gr. M. T., so that the circumstances of each conjunction may be seen at a glance. The present list extends only to the end of January; the concluding portion will be communicated next month.

			Ariel.		*Umbriel.*		*Titania.*		*Oberon.*	
		G.M.T.	Pos.	Dist.	Pos.	Dist.	Pos.	Dist.	Pos.	Dist.
1881.		h	°	″	°	″	°	″	°	″
Dec.	15	16	14·7	14·3	8·7	7·8	20·5	15·3	—	
		18	15·2	14·6	10·5	10·1	21·4	13·6	—	
		20	15·8	14·3	11·6	12·2	22·5	11·7	—	
		22	16·4	13·4	12·5	14·2	24·1	9·8	—	
	28	16	—		—		200·0	16·3	186·4	13·2
		18	—		—		200·8	15·0	187·5	14·9
		20	—		—		201·7	13·2	188·3	16·5
1882.										
Jan.	17	18	16·8	12·5	7·0	6·0	—		5·5	11·2
		20	17·7	10·5	9·7	9·7	—		6·8	12·9
		22	19·0	8·1	11·1	11·1	—		7·9	14·6
	18	16	—		—		16·5	30·1	12·2	28·5
		18	—		—		16·7	29·0	12·4	29·9
	23	20	195·3	15·0	—		199 6	16·0	—	
		22	195·8	14·6	—		200·3	14·2	—	
	24	20	—		195·3	21·0	—		189·9	18·3
		22	—		195·6	20·7	—		190·5	19·9
	25	0	—		195·9	20·1	—		190·9	21·5
	29	10	—		197·0	16·1	190·2	13·7	—	
		12	—		197·5	14·3	190·9	15·5	—	
		14	—		198·2	12·3	191·5	17·4	199·0	22·9
		16	—		—		192·0	19·1	199·3	21·4
		18	—		—		192·4	20·8	199·7	19·8
	31	10	—		16·5	17·5	—		9·4	15·4
		12	—		17·0	15·9	—		10·1	17·0

* In the Note "On the Apparent Conjunctions of the Satellites of *Uranus* with each other, 1881," published in the *Monthly Notices* of January 1881.

Note on Mr. Christie's Paper in the Monthly Notices for May 1881.

By E. J. Stone, Esq.

The remarks which Mr. Christie has inserted in the *Monthly Notices* for May 1881 are unfortunately of such a nature that they cannot close a controversy.

I certainly have not put words into Mr. Christie's mouth and charged him upon the strength of these words with fallacious reasoning. The fallacy which, in my opinion, invalidates Mr. Christie's work on these questions of refraction can be clearly stated, and it depends upon no misrepresentations of mine.

I have proved, by a re-calculation, that the residual errors given in my paper of 1867, December, are substantially correct: and that the Greenwich circumpolar observations 1857 to 1865, to the lowest altitudes observed, are well represented in mean results by refractions computed from the formula Bessel's Refractions $(1-0{\cdot}005)$. I have also shown that the Greenwich circumpolar observations which were reduced with these refractions, 1868–1876, are well represented. I have shown that Bessel's Refractions *unaltered* do not represent these Greenwich observations. These statements are mere matters of fact; the residual errors which prove them have been given over and over again in the course of the present discussion. The agreement between the Greenwich circumpolar observations and the diminished refractions may, of course, be solely due to systematic errors in the Greenwich results; but this is improbable in itself; and, if it were true, it would not prove that the change in the refractions adopted at Greenwich in 1868 was due to an error on my part, or was made upon *slight* evidence. The evidence afforded in favour of the diminished refractions by these Greenwich circumpolar observations is, as I have elswhere said, irresistible, unless some other alternative hypothesis can be brought forward which shall equally represent the facts, and which has *equal claims to be accepted as a possible solution of the problem of Astronomical Refraction.*

In 1868 we had no such alternative hypothesis. The broken, discontinuous, curve system with its three distinct tables of refraction, then in use at Greenwich, was considered only an unsatisfactory make-shift. The breaks of continuity, introduced into the adopted refractions, were fully recognised as impossible in nature. They had no other *raison d'être* than the facts, proved by Main, that if you would adopt Bessel's Refractions unaltered for the smaller zenith distances, and determine your colatitude under the same restrictions, then the error of the colatitude, thus determined, and the errors of Bessel's Refractions did not become sufficiently separated to be put clearly and distinctly in evidence until you reached a zenith distance of about 82°. But the error of Bessel's Refractions, in mean results, appeared to be

about 0″·9 at 82° zenith distance, whilst at 85° zenith distance the error had increased to about 2″·9. It was considered necessary, for practical applications, to represent the observations at low altitudes, and this was effected by the very simple expedient of throwing away the mean errors which Mr. Main had shown to exist in Bessel's tables. The system adopted, to effect this, was the use of three independent refraction tables—Bessel's Refractions to 82°; Bessel's Refractions × 0·9977 from 82° to 85°; and Bessel's Refractions × 0·9951 below 85° zenith distance. The arbitrary breaks thus introduced show at once that such a system cannot exist in nature. No proof of the legitimacy of the plan adopted has been attempted. But the large errors can, of course, no longer appear as "residual errors" in a discussion of observations reduced with refractions from which they have been thus arbitrarily removed; the smallness of such "residual errors" only proves that the observations under discussion are in substantial agreement with those from which Mr. Main originally determined the adopted corrections. It is the errors of refractions computed from the discontinuous, broken curve, system, abandoned in 1868, which Mr. Christie has compared in his curves and residuals with the errors which result from the use of refractions computed from the formula Bessel's Refractions × 0·995. The latter formula is continuous: it requires no greater number of disposable constants than are contained in Bessel's theory to represent in mean results all the Greenwich circumpolar observations 1857–1876 from the zenith to the lowest star observed. The refractions used by Mr. Christie are discontinuous. They are not computed from a single table: and, to secure an equal agreement between the computed refractions and the Greenwich observations, it requires three disposable constants instead of the one required by the refractions introduced in 1868. It was simply on these grounds that the diminished refractions were adopted in 1868 by Sir G. B. Airy.

It is the comparisons which Mr. Christie has instituted as *an alternative hypothesis*, to weaken the evidence in favour of the diminished refractions, between residual errors resulting from the use of refractions computed from this complex, arbitrary system with those arising from the use of Bessel's Refractions × 0·995, which constitutes the fallacy which, in my opinion, vitiates Mr. Christie's reasoning and statements on these questions of refraction. Mr. Christie may maintain that there is no fallacy in the institution of these comparisons. He is, of course, fully entitled to the benefit of his own judgment upon the point. I, however, consider it a serious fallacy—a fallacy which entirely destroys the force of his remarks on the slight evidence which these Greenwich observations afford in favour of the diminished refractions. The mere fact that it requires such a complex system with two additional constants to equally represent the observations is a proof that the evidence afforded by these Greenwich observations in favour of the diminished

refractions is indeed very strong. At all events, the fallacy to which I have called attention, such as it is, is not of my making. It runs through all Mr. Christie's work on the subject of refractions. It is not due to words which I have put into Mr. Christie's mouth. I should be utterly ashamed of myself if such a charge could fairly be brought against me.

The notice, "The Nadir Point Observation is to be taken at 179° 40′ + 0^{r}," to which Mr. Christie calls attention on page 344, meant exactly what it says—viz. that the readings were to be taken on the first revolution, or from 0^{r}·0 to 1^{r}·0. This is shown by the general practice to which it led. The practice was adopted, as I have before stated, to keep the correction for runs small for the Nadir Point Observation. If errors such as those given in the Introduction to the Greenwich Catalogue exist in the readings of the screws near 0^{r}·0, the supposed errors of the screws at other readings will change from the mere effect of these errors on the runs by such quantities as the following:—

Supposed Errors of Screws.

Runs started from	r 0·5	r 1	r 2	r 3	r 4	r 5
r						
9·9	″ −0·1	″ −0·2	″ −0·5	″ −0·7	″ −0·9	″ −1·2
0·1	−0·1	−0·1	−0·2	−0·3	−0·4	−0·5

I think that the magnitude of these differences will show that there may be some considerable advantages in keeping the run-correction small for an observation like the Nadir, which is common to all the observations of a night. If Mr. Christie cannot see the advantage of separating the effects of two distinct sources of error, I regret it, but I cannot help it.

Mr. Christie's statement that the constant error of −0″·8 in the Nadir observations was due to error of the screws about 0^{r}·0, which had suffered extra wear since 1868 from a preponderance of some 4,000 observations taken at this part, was, I thought, sufficiently disposed of when it was pointed out that instead of 4,000 additional observations there were only 108 such observations made with readings at and below 0^{r}·2, whilst there were 72 such determinations made at readings greater than 1^{r}·0 during a period of nearly two years—1868, February 1, to 1869, December 31. This would give less than 500 additional observations, instead of 4,000, during the period of 1868 to 1876. Mr. Christie, however, thinks that these facts do not concern him. The corrections which have been applied to the Greenwich Observations 1874–1875 for these supposed errors of screws are given in the following table, which is extracted from the Introduction to the Greenwich Catalogue, 1878:—

9·7	−1″·38	1·4	+0″·08	3·1	+0″·38
9·8	−1·13	1·5	+0·08	3·2	+0·22
9·9	−1·17	1·6	+0·18	3·3	−0·06
0·0	−0·89	1·7	+0·12	3·4	+0·05
0·1	−0·51	1·8	+0·05	3·5	+0·31
0·2	−0·41	1·9	+0·22	3·6	+0·33
0·3	−0·42	2·0	+0·47	3·7	+0·27
0·4	−0·09	2·1	+0·55	3·8	+0·22
0·5	+0·28	2·2	+0·66	3·9	+0·21
0·6	+0·34	2·3	+0·76	4·0	+0·19
0·7	+0·28	2·4	+0·52	4·1	−0·05
0·8	+0·19	2·5	+0·39	4·2	−0·19
0·9	+0·22	2·6	+0·52	4·3	−0·03
1·0	+0·30	2·7	+0·42	4·4	−0·17
1·1	+0·23	2·8	+0·15	4·5	−0·39
1·2	+0·23	2·9	+0·15	4·6	−0·51
1·3	+0·23	3·0	+0·32	4·7	−0·74

I point out the extreme rapidity with which the error changes near $0^{r}\cdot0$, that on and after $0^{r}\cdot5$ the changes of the corrections are, comparatively speaking, small. It appears, therefore, that if these errors are due to serious wear of the screws, the serious wear has been principally confined to the threads of the screws engaged at readings below $0^{r}\cdot5$. Now, Mr. Christie has himself stated that from 1868, February 1, to 1869, December 31, there were only 283 observations of the Nadir made at and below readings of microscope $A=0^{r}\cdot4$. If, therefore, we give the most liberal interpretation possible to the expression "the parts of the screw about $0^{r}\cdot0$," and understand it to mean all those parts of the screw which have been proved to be seriously defective, yet, even then, we should have less than 1,500 instead of 4,000 additional observations made near $0^{r}\cdot0$. But, in spite of these facts, Mr. Christie has thought himself justified in making such a statement as the following. "It seems a pity that Mr. Stone did not make himself better acquainted with the facts before making the confident assertion that 'whatever may have been the state of the screws near $0^{r}\cdot0$ in 1876 it certainly was not caused by the 4,000 observations made near $0^{r}\cdot0$ at my suggestion.'" It is extremely difficult to deal with such assertions in a way which can be regarded as satisfactory either to Mr. Christie or to myself.

In my opinion, neither 4,000 nor 6,000 additional Nadir observations made near $0^{r}\cdot0$ in a period of eight years would have led to any such serious wear of the screws as that indicated as existing in 1876 near $0^{r}\cdot0$. If all the observations were made

near $0^{r}{\cdot}0$, and the screws never worked far from this reading, such a thing might be conceivable; but in practice the screws are worked continually backwards and forwards over the whole range of the screws from 0^{r} to $5^{r}{\cdot}0$. That the mere running down of the screws once in the course of a night's work to $0^{r}{\cdot}0$ should lead to any serious unequal wearing of such screws as those in use at Greenwich is to me inconceivable.

In all screws the threads near the ends of the screws are defective, and are never intended to be used. If in some of the many adjustments of the instrument the indices of the screws have been shifted relatively to the screws, and thus some of the defective threads brought accidentally into use, the apparent wear of the screws would be accounted for; and this explanation would also show why the supposed serious wear has changed so rapidly near $0^{r}{\cdot}0$, and practically became insensible at and after $0^{r}{\cdot}5$.

I believe that this affords a key to the true explanation of these errors. But, at all events, I cannot regard the way in which Mr. Christie has attempted to determine the correction required by the screws at the different readings as satisfactory. I have already shown how rapidly these supposed corrections vary with every change of starting-point for the run-correction. To attempt, therefore, an investigation of the errors of the screws or the corrections which should be applied to observations without taking the runs actually used in the reduction of the observations into account can, in my opinion, only lead to serious misconceptions with respect to the errors of the screws and no inconsiderable errors in the corrections applied to the observations.

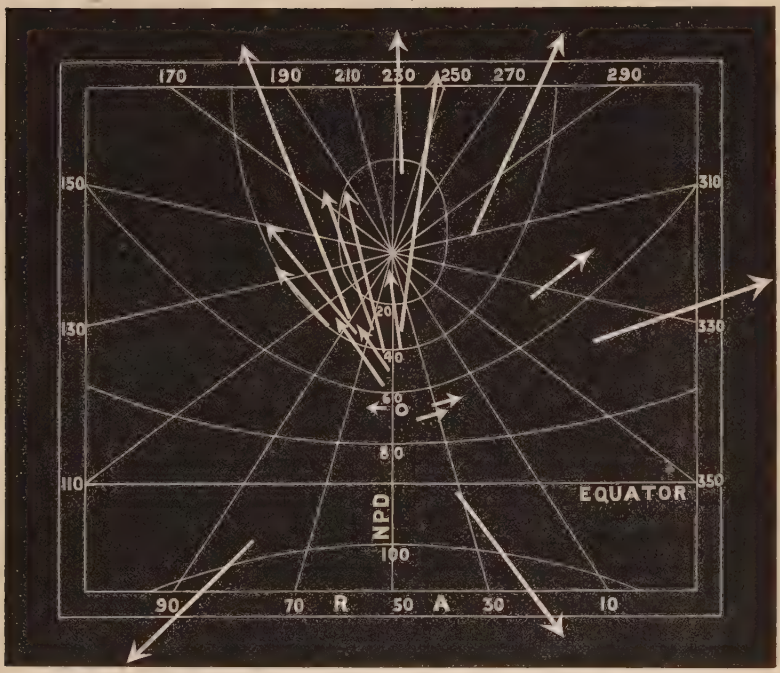
Showers of Large Meteors. By W. F. Denning, Esq.

I. On Oct. 29, 1881, at $9^{h}\,58^{m}$ I saw a fine meteor, quite $= 1^{st}$ mag., descending obliquely to a point slightly below *Fomalhaut* on the S. S. W. horizon. The nucleus was distinctly pear-shaped, and it left a thick trail of luminous flakes. Path about 20°, traversed in 2 seconds. Shortly afterwards I saw two other meteors, 2nd mag., evidently from the same radiant, W. of the *Pleiades*.

The shower to which these meteors belonged is one of very special character. At the end of October and during the first few nights of November it furnishes many brilliant fireballs, and in conjunction with that closely bordering shower, the Taurids, renders the epoch a notable one for large meteors. The radiant point, as I derived it, Oct. 28–Nov. 13, 1877, from 32 paths, was at $43° + 22°$, and the shower struck me as exceptional both on account of its activity and the brilliancy of its meteors. In appearance they are similar to the Taurids, the motion being somewhat slow, and the nucleus is almost invariably accompanied by

a thick trail of sparks or luminous flakes. The position of the radiant is between *Taurus* and *Aries*, south of *Musca*, and fully 15° west of the true Taurids.

During the last few years many fine meteors have owed their origin to this stream, and I have collected some of the best instances together and projected the apparent paths upon a diagram as follows:—



Paths of 18 Fireballs, directed from a Radiant at 48° + 22°, Oct. 25–Nov. 6.

The point of divergence is fairly precise at 48° + 22°, and considering the character of the observations the agreement is very satisfactory. Showers of small meteors very carefully recorded by one and the same observer often show a sharply defined radiant, but here, where the results of many different observers are incorporated, we can hardly expect the same close accordance. Moreover the direction of flight in the case of large fireballs, such as these, is often not very accurate, from the circumstance that the apparition is sudden and unexpected, so that the observer is often taken unawares. The glare and brilliant effect are frequently the cause of distracting the observer's

Ref. No.	Year 1800+ and Date.	Mag.	Observed Path From α δ	Observed Path To α δ	Length of Observed Path.	Notes.	Observer and Place.
1	54, Oct. 31	♀	235°+73°	233°+60°	13°	Streak	Heis, Münster.
2	63, Nov. 6	♃	*340+23	300+10	40	Streak; curved path ...	Heis, Münster.
3	66, 3	2×♃	* 63+50	185+69	54		Crumplen, London.
4	66, 3	2×♃	* 30+22	19+23	10		Crumplen, London.
5	66, 6	♃	* 67+51	172+65	51		Penrose, Wimbledon.
6	69, 2	♃	*335+29	321+26	13	Swift	Zezioli, Bergamo.
7	69, 3	♃	† 83− 7	93−13	12	Very fine. Streak 3° ...	Tupman, Mediterranean.
8	69, 3	♀	* 95−15	110−24	17	Very fine. Train of sparks	Tupman, Mediterranean.
9	72, 1	♀	*100+48	132+49	21	Duration 0·5 sec.	Tupman, Portsmouth.
10	72, 3	⅓ = ☽	‡ 89+50	150+41	42	2·5 sec. Tail of red sparks	McClure, Glasgow.
11	73, Oct. 26	V. large	* 56+31	105+57	42	Train of sparks	"F. T. S," Thruxton.
12	77, Nov. 1	♃	44+56	245+51	71	Slow. Bright train ...	Denning, Bristol.
13	77, 4	♃	* 55+22	61+22	5	V. slow. Thick spark-train	Denning, Bristol.
14	77, 4	>♀	‡350− 1	327−17	28	2½ sec. Train 15° long. ...	Wood, Birmingham.
15	77, 4	♀	† 10− 0½	344−10	28	1 sec. streak	Backhouse, Sunderland.
16	77, 7	♂	100+59	190+51	49	2½ sec.; slow; red	Walpole, York.
17	78, 3	Brilliant	*310+61	266+42	32	Streak 2 sec.	Downing, Greenwich.
18	79, 5	Fireball	* 48+50	115+87	38	Train 2 sec.	Trouvelot, Cambdge., U.S.
19	80, Oct. 25	>♀	‡ 55+40	76+52	18	3½ sec.; streak	Sawyer, Cambridge, U.S.
20	80, 30	>♀	† 38+18	26+22	12	Streak; 25 sec.	Denning, Bristol.
21	80, 30	>♃	† 31− 1½	16−17	21	1½ sec.	Baxendell, Manchester.
22	80, Nov. 1	♃	*275+56	257+43	17	Train of orange flakes ...	Corder, Writtle.
23	81, Oct. 29	♃	*360−22	342−33	20	2 sec.; thick train ...	Denning, Bristol.

* Radiant well defined at 48°+22°. † From an apparently sub-radiant at 47°+15°. ‡ These conform to a radiant slightly N. in Musca.

attention from the immediate determination of the path. This is left until both the nucleus and train have died away, so that in fixing the approximate course the memory, so often an untrustworthy guide, has to be relied on. In the subjoined table the paths of 23 large meteors apparently conforming to this shower are given.

The average length of path is 28°·4 (23 meteors).

A few of these may quite possibly have been Taurids.

The catalogues of meteor observers probably contain many other fireballs belonging to this remarkable stream or its closely-allied shower, the Taurids.

The great meteor of 1859, Oct. 25, $7^h\ 15^m$, seen in Ireland, and estimated= ☽, was from a radiant near *η Tauri* at $41° + 17°$ (or $54° + 18°$) $\pm 10°$, and the bright meteor of Nov. 1, 1860, $8^h\ 30^m$, was directed from the same shower at $55° (\pm 10°) + 20°$.* Another large meteor seen in the evening twilight on Nov. 8, 1876, agreed with this radiant near *η Tauri*, $53° + 20° (\pm 5°)$.† On Nov. 5, 1876, about 9 P.M., a large bolide giving a flash brighter than moonlight was observed at Choisi le Roy, in France, moving from *α Aurigæ* to *α Ursæ Majoris*, and leaving a streak from which the path was recorded.‡ The following night at Orsay, near Paris, A. Guillemin describes a fine meteor not much smaller than the moon's disc, which travelled very slowly southwards, in an horizontal direction, about 20° or 25° above the E.N.E. horizon. The meteor had a globular nucleus, and left a bright streak.§ From the directions of the apparent paths it is obvious these meteors were severally projected either from the radiant of the Taurids or from that of the shower adjoining it, S. of *Musca*. Both are equally remarkable for their numerous and brilliant members. They appear to attain a maximum early in November, though many meteors from nearly the same point below *Musca* are seen early in October, and the Taurids, commencing in that month, are prolonged late into November. I have observed the Muscids as an active and sharply-defined shower on Oct. 8, 15, and Nov. 13, and the Taurids with equal distinctness on Nov. 8, 13, 20 and 27. Greg's shower R_3 is evidently identical with the former. He gives the duration from Oct. 18 to Nov. 14, and the place as $43° + 26°$. Sawyer detected it on Oct. 21–22 at $47° + 27°$, and Corder has seen many of its meteors in Oct. and Nov. from the centre $43° + 15°$.

II. In the morning twilight on July 25, 1881, I saw a very fine meteor, with vivid flash and streak, in *Aquarius*. I marked its short path accurately from the streak it left. The meteor was evidently much foreshortened and close to its radiant E. of *β Aquarii*. This position agreed with one I had found as the

* B. A. Report on Luminous Meteors, 1880, p. 4.
† *Monthly Notices*, vol. xxxvii. p 210.
‡ *Comptes Rendus*, vol. lxxxiii. p. 862.
§ Ibid. p. 922.

result of an investigation of the fireballs of July 25–31 (*Observatory*, Sept. 1879, p. 130), and it also exhibits a distinct confirmation to the fine shower seen by Sawyer at the end of July 1880, when he recorded 28 of its meteors and describes them as "very bright, generally slow." This shower in conjunction with another fireball radiant at 303°+12°, and two rich streams of meteors at 32°+53° and 341°−14° go far to make the end of July a meteoric period of exceptional strength.

The following table includes the observed paths of 16 fireballs recorded at various stations (chiefly by foreign observers). They conform closely to the centre near *β Aquarii* :—

Ref. No.	Year 1800+ and Date.	Mag.	Observed Path From α	δ	To α	δ	Length of Path.	Observer or Authority.
1	64, July 30	♀	278°	+38°	210°	+55°	47°	Heis, Münster.
2	64, 30	♃	267½	+30	221	+41	39	Weber, Peckeloh.
3	67, 31	♃	345	+33	12	+54	28	Zezioli, Bergamo.
4	70, 27	♃	346	− 9	355	− 9½	9	Tupman, Meditn.
5	72. 25	♃	293·6	+42·9	193·3	+52·3	63	Konkoly, O-Gyalla.
6	73, 25	♀	357·8	+ 0·5	6	+ 1·7	8	Nagy, O-Gyalla.
7	73, 26	♀	262·2	+17·4	212·5	+24·1	47	Nagy, O-Gyalla.
8	73, 30	♀	294	+ 3	207	+28	81	Klinkerfues, Göttingen.
9	73, 30	♀	258	+10	197	+22	60	Thraen, Dingelstaedt.
10	75, 27	♀	146·3	+71	139·6	+56·3	15	Nagy, O-Gyalla.
11	75, 27	♀	273·7	+27·9	262·7	+33·4	11	Nagy, O-Gyalla.
12	78, 30	♀	330	−22	332	−27	5	Denning, Bristol.
13	79, 26	♃	16·9	+20	41·8	+26·8	24	Konkoly, O-Gyalla.
14	79, 28	♀	258·2	+14·5	233·1	+23·5	25	Konkoly, O-Gyalla.
15	79, 30	¼ = ☽	342	− 8	360	− 3	19	Payne, Suffolk.
16	81, 25	♀	336	− 5	340¼	− 4	4½	Denning, Bristol.

Radiant point at 324°−9°. Average length of course=30°·3. The shower is well defined a few degrees S. E. of *β Aquarii*; the meteors are brilliant, rather swift, and generally with streaks. It has been previously observed as follows :—

July 25–31	324°− 6°	Schmidt.
1870, July 28	326−13	Tupman.
1880, July 28–31	330− 6	Sawyer.
28–30	328−15	Sawyer.

Including with these the place of the fireball radiant as above 324°−9°, we derive a mean position at 326°·4−9°·8. The maxi-

mum occurs on July 28–30, and this shower undoubtedly plays an active part in rendering the last few nights of July a notable fireball epoch. It should not be confused, however, with a contemporary shower further E., 15°, which I observed in considerable strength in 1878,* and which had been thoroughly well determined by Tupman at the end of July 1870.

III. Another shower,† S. of ε *Persei*, Sept. 6–15, deserves mention as one consisting of a large proportion of brilliant meteors. It was well seen at Bristol in 1877. The meteors belong to the swift streak-leaving class, and the display apparently attains a maximum on Sept. 6–8. I have observed the following bright meteors belonging to it during the past few years :—

Ref. No.	Year 1800+ and Date.	Mag.	Observed Path. From α δ	To α δ	Length of Path.	Notes.
1	74, Sept. 6	2	275 + 20	255 − 12	37	Swift; streak.
2	77, 7	1	73 + 53	85 + 60	10	Streak 3 sec.
3	77, 15	2	56 ± 0	55 − 6	6	Swift; streak 4 sec.
4	78, 8	> ♀	246 + 21	244½ + 5	16	Swift; streak 4° 20′.
5	79, 7	>1	342 + 27	317½ + 11	28	Swift; streak.
6	80, 6	2	294 + 7½	279 − 8	21	Very swift; streak.
7	80, 6	1	344 + 65½	310 + 61½	15	Very swift; streak.

The radiant point is at about 61° + 36°, as I carefully derived it in 1877. The shower is a very prominent one and is obviously the same as No. 64 (at 66° + 40°, Sept. 7–15) in Tupman's catalogue and No. 147 (at 60° + 32°, Sept. 8) in the list deduced by Schiaparelli from Zezioli's observations. It is best observable in the morning hours when the radiant is high. The first half of September is, similarly to the first few nights of November and the last few nights of July, a very well defined period of fireballs, and I believe that the majority of those appearing on the 6–8th are directed from this shower of ε Perseids. It will be very important in future years to look out at the several epochs referred to for further confirmation of these showers of large meteors, for there is no doubt of their annual recurrence with marked intensity.

* See *Monthly Notices*, vol. xl. p. 126 (Jan. 1880), and *The Observatory*, Sept. 1878, p. 164.

† See *Popular Science Review*, Oct. 1880, p. 335, which contains a diagram of 86 paths belonging to this shower as observed by the writer and others.

Ashleydown, Bristol :
1881, *November* 9.

Observations of Comet c, 1881. By T. W. Backhouse, Esq.

1881. Time.	Brightness of Head.	Length of Tail.	Width of Tail.	Central Line of Tail. passes, or points to	Central Line of Tail. at distance from Nucleus.	Mode of Obser	Hindrances.
July 27, 12 10		$1\frac{1}{4}°$		at angle of 15° above β Aur.		n. e.	Twilight.
12 20		1°				(38)	,,
		$1\frac{1}{2}°$				(20)	,,
12 25	= 55 Auri.; slightly fainter than 56.	2·7°	0·7°	$\frac{2}{3}$ (β, π) Aur.		(2·5)	,,
29, 12 17	= 21 Lyncis.	5·8°				n. e.	
12 25		$6\frac{1}{2}°$	$\frac{1}{2}°$	$\frac{3}{5}$ (41, 36) Aur.	$6\frac{1}{2}°$	(2·5)	
Aug. 4, 12 50		$6\frac{3}{4}°$	$\frac{2}{3}°$	$\frac{1}{3}°$ north of 46 Aur.	6°	n. e.	Twilight.
12 55				at angle of 15° north of 57 Aur.	$2\frac{1}{2}°$	(3·5)	,,
5, 12 23			11′ at 1° off nuc.			(20)	Haze.
12 25	Considerably brighter than 21 Lyn.	shorter than on 4th.				n. e.	,,
9, 13 15	Ditto, and rather fainter than κ Urs. Maj.†	$\frac{7}{8}°$				(3·5)	Moon.
13 25	Just visible.					n. e.	,,

1881. Time.	Brightness of Head.	Length of Tail.	Width of Tail.	Central Line of Tail. passes, or points to	Central Line of Tail. at distance from Nucleus.	Mode of Obser.	Hindrances.
Aug. 10. 10 40		2°				(3·5)	Moon.
11 0		1°				(20)	,,
14, 10 50	Rather fainter than θ Urs. Maj.	$4\frac{3}{4}$°				n. e.	Not very clear.
18, 10 0	,, brighter ,,	$8\frac{1}{2}$°	$1\frac{1}{2}$°	about $\frac{1}{2}$° f v Urs. Maj.	$8\frac{1}{2}$°	,,	Town smoke and light.
,,				229 P. ix.	$3\frac{1}{2}$°	(3·5)	
10 50			12′ at 12′ off nucleus; also at 95′ off.			(20)	
12 15			16′ at 12′ off nucleus.			,,	Moon.
19, 13 10		$10\frac{1}{4}$°	$1\frac{1}{2}$°			n. e.	,,
,,				36 Urs. Maj.	5°	(3·5)	,,
20, 9 40	Considerably brighter than θ or ψ Urs. Maj.					n. e.	Twilight.
10 15		8°	$1\frac{1}{2}$°	β Urs. Maj.	8°	specs.	Town (?) light.
7, 8 21	(Invisible with naked eye.)	$\frac{3}{4}$°	$\frac{1}{4}$°	$\frac{11}{14}$ (37, 41) Com.		(3·5)	Twilight.
8 40	Much brighter than β Comæ.					n. e.	,,
28, 8 49	Not quite = η Boötis.*	$2\frac{3}{4}$°	$\frac{1}{4}$°	slightly *np.* 14 P. xiii.		(3·5)	,,

* Means that the object, compared with Comet *c*, was more favourably situated; † less so.

My observations on this Comet were made at Sunderland. The accompanying table gives the brightness of its head—*i.e.* of the nucleus and the surrounding nebulosity; the length and width of the tail, the greatest width being given unless anything is said to the contrary; and the direction of the tail—*i.e.* of the central or brightest line, as measured from the nucleus. When the tail was curved, the next column gives the part to which the direction refers. The last column but one gives the mode of observation, n. e. indicating the naked eye; specs., spectacles to correct my short sight (which usually made no perceptible difference); (3·5), opera-glasses, power 3·5, aperture $1\frac{1}{2}$ in.; (2·5), a smaller pair of opera-glasses; and (20) and (38), these powers of my $4\frac{1}{4}$-in. achromatic. On each night I have given the results of the best mode of observation for that night. The last column gives the more important hindrances to a perfect view. Of course the low altitude of the Comet prevented it from ever being seen so clearly as if it were high up.

The latter part of the time of the Comet's apparition the weather was unusually cloudy.

The measurements are all taken from my drawings, or otherwise estimated.

Remarks on the Tail.

July 27.—Straight.

July 31.—Slightly curved, concave to south (2·5).

August 4.—Strongly curved (n. e.).

August 14.—I believe, slightly curved, concave to *sp*.

August 18.—Curvature not certain with naked eye, but slight with (3·5).

August 19, 13^h 10^m.—Slightly curved near the nucleus, concave to *p*, as seen with opera-glasses. With the naked eye it is straight, but as the *f* edge extends much further than the *p* edge, it has the appearance of a slight curvature, concave to *f* 37 *Urs. Maj.* just within the *f* edge.

August 20, 10^h 15^m.—Straight. I believe I can see it nearly to *a Urs. Maj.*, but am sure of it only to near β. There is a broad extension of the tail on the *p* side in its southern half.

August 28, 8^h 49^m.—Straight. The *sf* edge most definite; 14 P. xiii just within it.

Telescopic Notes.

August 18, 10^h 50^m.—From near the nucleus to a distance of a degree from it, the brightest part of the Comet is a narrow ray, almost straight, only 1′ or 2′ wide. Preceding this the tail is very faint, except near the nucleus, and at a distance of 1° or $1\frac{1}{2}$° from the nucleus fades out altogether, the *p* edge of the tail being, beyond that, almost a continuation of the narrow ray.

There is an indefinite projection from the nucleus towards *np*, to a distance of 12′ or 15′ from it. The *f* edge of the tail is very definite.

August 19, $13^h\ 10^m$.—The bright central ray broader and less definite, and more decidedly curved, concave to *p*. The *f* edge, which is very strongly curved in the same direction, is brighter than the space between it and the central ray to a distance of 25′ from the nucleus; which was not the case last night.

Notes on the Spectrum of Comet c, 1881, *as seen with a Browning's Miniature Spectroscope on the* $4\frac{1}{4}$*-in. Telescope.*

July 27.—Spectrum consists chiefly of the three usual bright bands. The continuous spectrum faint, unlike the nucleus of Comet *b*.

August 19, $13^h\ 30^m$–$14^h\ 0^m$.—Spectrum much the same, but brighter. The three bright bands by far the most conspicuous part. They are the only bands I can be sure of. The continuous spectrum of the nucleus begins abruptly at about half as far off the least refrangible band as that is off the middle one; and I suspect a bright line at that point.

Sunderland:
1881, *October* 8.

Observations of Comet b, 1881, *made at Stonyhurst Observatory.*
By Rev. S. J. Perry.

The position of Comet *b*, 1881, has been observed here on nearly every available night since it was first visible in this latitude, but the weather has very much interfered with the completeness of the record. The observations of June 27 and July 1 were S.P. transits, and all the other positions were taken with the 8-inch Equatoreal, the comparison stars having been carefully identified.

	G.M.T.	R.A.	N.P.D.
	h m	h m s	° ′ ″
1881, June 25	12 11	5 42 51·3	36 29 2·4
27	11 38	5 52 46·3	29 46 19·4
July 1	11 50	6 20 53·5	19 45 6·3
11	10 27	8 40 44·3	8 52 59·1
14	11 6	9 39 1·2	7 57 43·1
19	10 2	11 3 7·6	7 46 56·9

		h m	h m s	° ′ ″
July 20	G.M.T.	11 16	11 17 37·2	7 51 32·6
27		11 18	12 32 24·0	8 52 59·3
31		11 1	13 1 2·9	9 33 49·9
Aug. 1		11 2	13 6 36·7	9 45 34·9
Sept. 19		9 29	16 22 15·7	15 55 5·1

Stonyhurst Observatory, Whalley:
1881, *November* 7.

Elements of Comet b, 1881. By H. T. Vivian, Esq.

On the appearance of the Comet in June of this year I made a series of measurements with a view to the determination, at least approximately, of its orbit. Its angular distance from two Nautical Almanac stars was measured on every available evening with a carefully-adjusted pocket sextant, the time of the observation being taken from a watch previously compared with a regulator. The stars chosen were *α Persei*, and *α Ursæ Majoris*. No correction for differences of refraction was applied, as it was not thought desirable to attempt an accuracy not within the capabilities of the instrument.

Three of the deduced positions were selected for the computation of elements, viz.:—

	G.M.T. h m	App. R.A. h m s	App. N.P.D. ° ′ ″
June 24	11 30	5 37 50	40 36 31
29	10 35	6 6 37	24 38 58
July 4	10 50	6 52 17	15 5 39

and from these I have computed the following parabola:—

T = 1881, June 19·0433 G.M.T.

π = 270° 37′ 22″ } Apparent Equinox,
Ω = 271 8 47 } June 30

i = 63 3 21

log. q = 9·8803409

Motion Direct.

The calculated middle place compared with the observed gave:

C − O Longitude − 4″ Latitude + 70″.

In the present state of astronomical science, such an attempt as this may perhaps be considered useless, but it will serve to show that something may be done with very inadequate means, and that such observations, in the absence of better, might furnish an orbit sufficient for the recognition of the Comet on its return.

November 3, 1881.

On the Orbit of Denning's Comet. By Professor Winnecke.

From the observations, Marseilles, October 5, Dunecht, October 12, Strassburg, October 19 and 28 (made by me with the refractor of 18 Paris inches aperture), Dr. Hartwig, assistant of the Observatory, and M. Wutschichowsky, from Pulkowa, have deduced the following orbit of Denning's Comet:—

T = 1881, Sept. 13·1697 Berlin M. T.

$\pi - \Omega$ =	312° 11′ 22″	M. Eq. 1881·0
Ω =	66 4 2	,,
i =	6 52 36	,,
ϕ =	55 34 7	
log q =	9·859955	
log a =	0·616427	
Period =	3070^{d}·7.	

The differences (Observed − Computed) are:—

	October 5.	October 12.	October 19.	October 28.
$\Delta\lambda$	+1′·5	−0″·6	+5″·0	+0″·1
$\Delta\beta$	−0·2	−2·5	+2·2	−0·1

The orbit of the Comet is extremely interesting by its close approximation to the orbits of Venus, the Earth, and Jupiter. M. Hartwig and M. Wutschichowsky find:—

Helio. Long.	Distance between the orbits of	
32°	☄ − ♀	0·0215
83·5	☄ − ♁	0·0359
174	☄ − ♃	0·50
222	☄ − ♃	0·164.

The Comet was by no means *bright* on October 28, when I saw it for the last time. It is therefore to be hoped that some of the very powerful telescopes in England may be directed to this the first Comet discovered in that country for many years. Its places given by the orbit are:—

12h. Berl.	R.A.	Dec.	log r	log Δ
	h m s	° ′ ″		
1880, Nov. 14	10 35 30·7	+14 41 5	0·10699	0·01993
15	36 34·5	42 21		
16	37 35·9	43 49		
17	38 35·0	45 28		
18	39 31·7	47 18	0·12343	0·02399
19	40 26·0	49 21		
20	41 17·8	51 37		
21	42 7·3	54 5		
22	42 54·2	56 47	0·13926	0·02707
23	43 38·7	59 42		
24	44 20·6	15 2 51		
25	44 59·9	6 14		
26	45 36·7	9 50	0·15451	0·02931

Strassburg:
1881, *November* 8.

Approximate Positions of Comet b, 1881, *deduced from observations made at the Adelaide Observatory.* By C. Todd, Esq.

Date.		R. A.	Δ	Station.	✱ of Comparison.
	h m	h m s	° ′ ″		
May 28	8 0	5 1 25·	32 22 7″	Adelaide	α Columbæ.
29	7 20	5 1 51·7	31 39 39·	,,	BAC 1564.
30		5 2 21·8	30 51 2·	,,	,, 1615.
30	7 33	5 2 26·12	30 50 49·	,,	,, 1564.
31	7 8	5 2 54·6	30 0 1·	,,	,, 1615.
June 1	6 48	5 3 32·8	29 2 58·	,,	Washington 2173.
5	6 10	—	24 5 0	,,	
12	6 0	5 11 38·4	8 11 39·	,,	Rigel.
12	18 30	5 12 13·4	6 26 21·	,,	τ Orionis.

Physical Observations of Comet b, 1881, *made at Forest Lodge, Maresfield.* By Captain W. Noble.

Observing the Comet from $11^h\ 30^m$ to $12^h\ 30^m$ L.M.T. on the night of June 24, with a power of 42 on my 4·2-inch Ross Equatoreal, the nucleus and its surroundings presented the aspect rather indicated than drawn with absolute fidelity in the accompanying sketch numbered 1. From the brilliant nucleus there extended towards the N. and E. a line of light into the tail. This seemingly expanded into a fan-shaped aigrette to the S. and E. of the nucleus. A small aigrette of light also issued from the nucleus to the south and west of it. I noted that the very smallest stars seen through the tail lost nothing of their brilliancy. I tried my star spectroscope upon the head of the Comet with the

Comet b 1881.

(Observed by Captain Noble at Forest Lodge, Maresfield.)

Fig. 1.

June 24.
12^h L.M.T.
(Power 42.)

Fig. 2.

June 25.
$9^h\ 35^m$ L.M.T.
(Power 42.)

slit as much closed as its light would permit, but failed to get anything but a continuous spectrum.

On the succeeding night, that of June 25, a most remarkable change had taken place in the appendages of the nucleus. Instead of appearing with any jets or line issuing from it, it was surrounded by two sectors of light placed unsymmetrically round it in a way which will be best understood from drawing No. 2. The nucleus itself presented the aspect of a star of the first magnitude, and seemed to be connected with the inner concave edge of the interior sector by a kind of radiating hazy luminosity. Viewing the Comet now at $10^h\ 5^m$ L.M.T. with the star spectroscope, I at once saw a gaseous spectrum superposed on a continuous one, the most prominent line being in the bluish-green. As the night darkened the gaseous spectrum became very pronounced, and the continuous one of the nucleus lay along it as a brilliant line of light. I further noted that the strange arrangement of sectors, which I have drawn, and which earlier seemed to bound the Comet's outline, as it were, were now at some distance inside the coma.

The indifferent weather prevented any further observations until June 28, when I caught the Comet at intervals from $11^h\ 15^m$ to $11^h\ 45^m$ through rifts in huge drifting cumulus clouds. The nucleus had certainly diminished, and the sectoral arrangement surrounding it had changed notably in form. It gave the idea of spouting from the nucleus, but it was very fuzzy and ill-defined, and sketching was very difficult.

On the night of the 29th, which was clear, the nucleus had unmistakably diminished—or perhaps it would describe it better to say contracted, as it was decidedly less planetary and more stellar in its aspect than it was on the first night that I observed it. I noticed too (as I did on the previous night) that the nucleus was much farther within the coma than it was at the date of my earlier observation. In my sketch No. 4 it will be seen that the two sectors of light emanating from the nucleus—

Fig. 3.

June 28.
$11^h\ 30^m$ L.M.T.
(Power 42.)

Fig. 4.

June 29.
$11^h\ 20^m$ L.M.T.
(Power 74.)

the preceding one being the brighter—give something of the effect of a sea-gull in flight; an 8–9th magnitude star, too, over which the nucleus passed almost centrally, will be seen just S. of it.

By June 30 the nucleus had shrunk very perceptibly indeed, and was more stellar than ever. With a power of 74 it looked like a 3rd magnitude star, from which pointed a hazy aigrette of light, bounded on the *s.f.* side by a dark sector. Faint traces existed of the line of light which was such a feature on the night of the 24th, but it was very short. One particularly noteworthy feature I have tried to indicate in sketch No. 5. It was this: that outside of the parabolic outline proper of the Comet was a ragged, hazy, ill-defined edge. I left home on the day after this last observation, and on my return during the second week in July the Comet had ceased to present any telescopic features of interest.

Physical Observations of Schäberle's Comet (*c*, 1881).

August 21, 9^h to $10^h\ 15^m$ L.M.T.—The aspect of the tail was uniformly nebulous, but it was straighter and better defined on

the following side. Exchanging the power of 42 for one of 115, I saw that the nucleus proper was an exceedingly minute point, a considerable distance within the head. Nothing whatever in the shape of a sector, jet, or aigrette of light was visible. Viewed in the spectroscope, a very bright and distinct spectrum of carbon

FIG. 5. *Schäberle's Comet* (*c* 1881).

June 30.
$11^h\ 30^m$ L.M.T.
(Power 74.)

August 24. $9^h\ 30^m$ L.M.T.
As seen in a field-glass
magnifying 4 diameters.

was seen, the three bright lines being crossed by a horizontal continuous one, presumably arising from the minute nucleus.

My sketch of this Comet represents it as viewed in a field-glass, magnifying 4 diameters, on August 24, from 9^h to 10^h L.M.T. I drew it for the strange, faint second tail, or bifurcation of the first one. Viewed with a Nicol's prism in the Equatoreal, the whole coma exhibited distinct traces of polarisation.

Occultation of 13 *Capricorni by the Moon*, 1881, *October 2.*

The star disappeared instantaneously at the Moon's dark limb at $23^h\ 1^m\ 6^s{\cdot}3$ L.S.T.$=10^h\ 14^m\ 3^s{\cdot}5$ L.M.T. Power, 154.

Discovery of Comet c, 1881. By Captain Irwin Maling, Colonial Secretary, Grenada, West Indies.

(*Communicated by the Secretaries.*)

I first observed a Comet of considerable magnitude on July 14 at 8 P.M. At that time it seemed to be about 20° from the horizon directly under the Pole star, and to be travelling a course from N.N.W. to S.W. It was passing through the constellation *Camelopardus*. The nucleus was bright, about the size of the most northerly star in *Camelopardus*. The nebulosity round the nucleus was very bright, and of a distinctly oval form; the tail brush-shaped, and pointing to the N.E. A bright star was visible south of the nucleus, and another at the lower extremity of the tail. On the 15th, at the same hour, I took advantage of a clear sky and night, and sketched the Comet,

which, I am happy to say, proved to have then attained its greatest splendour. The 16th and 17th, it was too cloudy for observations. On the 18th I saw it dimly, but it had passed the star that was south of the nucleus on the 15th. I again saw the Comet on the 21st indistinctly. It had travelled westerly, and certainly with a northerly declination. On the 22nd, no observation (cloudy). The 23rd was specially favourable for observation, and I was enabled to confirm my impression of the 21st —that the Comet was travelling away from us in a northerly and westerly direction; and further that on the 18th it had attained the most southerly point of its orbit. 26th: Comet scarcely visible to the naked eye. With my glass I am able to observe that the Comet is continuing its northward and westward course. It being the rainy season here has prevented me from making more constant and accurate observations.

All these were ocular observations, only aided by a small field-glass, without any instruments or information as to any Comet being expected. Under these circumstances my conclusions may or may not be correct, and on this point I should be pleased to be informed by anyone who has had more favourable means and opportunities of observing this Comet.

Grenada:
1881, *July* 27.

Sextant Observations of Comet b, 1881.

Two series of distances of Comet *b*, 1881, from fixed stars, measured with the sextant, have been received from the Rev. S. S. O. Morris, H.M.S. *Garnet*, S.E. Coast of America, and from Lieut. Bertram Gwynne, H.M.S. *Garnet*, Sandy Point Road, Straits of Magellan, respectively. The former were made on May 30, 31, June 1, 2, 3, 4, 5, 6, 7, 8, 9, 13; and the latter on May 31, June 1, 2, 3, 4, 5, 6, 7, 8, 9, 12, 13.